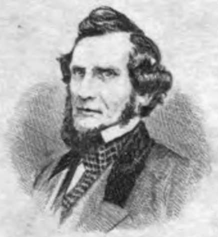

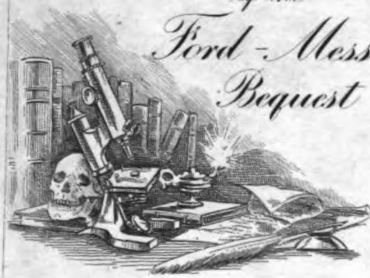

PROCEEDINGS

OF

THE ROYAL SOCIETY

OF

EDINBURGH.

VOL. III.

DECEMBER 1850 TO APRIL 1857.

EDINBURGH:
PRINTED BY NEILL AND COMPANY.
MDCCCLVII.

CONTENTS.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1850-51. No. 40.

Sixty-eighth Session.

Monday, 2d December 1850.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read :—

1. Description and Analysis of Gurolite, a new Mineral Species. By Dr T. Anderson.

The mineral described and analysed by the author was found at Stow, in Skye, where it occurs associated with apophyllite, stilbite, and other zeolitic minerals. It is found principally in a compact basalt, different from that in which these minerals are most abundant, and which appears to have been produced by a different eruption of basaltic matter.

Gurolite occurs in the form of radiated crystalline masses with a fine lustre. It cleaves readily parallel to the plates of which the concretions are composed, and its hardness is about 3. Before the blow-pipe alone it swells up, loses water, and finally fuses with some difficulty into an opaque glass. Its analysis leads to the chemical formula $2\ (Ca\ O\ Si\ O_3) + 3\ HO$.

The author referred to the relations which this mineral bears to the other silicates of lime, of which three are already known, the names and formulæ of which are as follows :—

Wollastonite (tabular spar),	$2\,CaO\,3\,SiO_3$.
Kalk-trisilicat of Gjellebäck,	$CaO\,SiO_3$.
Gurolite, . . .	$2\,(CaO\,SiO_3) + 3\,Ho$.
Dysclasite, . . .	$3\,CaO\,4\,SiO_3 + 6\,Ho$.

It thus appears that gurolite is the same silicate of lime as the kalk-trisilicat, in union with water, and that its relation with dysclasite is such that two equivalents of gurolite differ from one of dysclasite by a single equivalent of lime only.

2. On the Constitution of Bebeerine. By Dr A. Von Planta.

The author commenced his paper by referring to the analyses of Maclagan and Tilley, which gave for the composition of bebeerine a formula precisely the same as that of morphia, but as that formula appeared to require confirmation, he had undertaken the careful re-investigation of bebeerine.

In the commencement of his experiments he had employed the same process for the purification of bebeerine as that recommended by Dr Maclagan. He soon ascertained, however, that in this way it was impossible to obtain it in a state of absolute purity, as even when every care had been taken, it always retained a small quantity of a substance resembling tannine, which caused it slowly to gain weight in the process of drying the water bath. After several trials he found the following process to yield pure bebeerine :—The substance already partially purified by Maclagan's process was dissolved in acetic acid, and mixed with a solution of acetate of lead and caustic potash gradually added as long as a precipitate of bebeerine mixed with oxide of lead was obtained. The precipitate was then washed and dried and extracted with absolute ether, and the filtered ethereal solution distilled. A syrupy residue was obtained, which was dissolved in absolute alcohol, and mixed with a large quantity of water.

Bebeerine so prepared is a perfectly colourless and inodorous powder persistent in the air and highly electrical. It fuses at 356° into a colourless glassy mass. The quantity employed for analysis was from two different preparations, and gave the following results :—

	I.	II.	III.
Carbon, . . .	73·06	72·85	72·82
Hydrogen, . . .	6·80	6·99	6·89
Nitrogen, . . .	4·53	4·53	4·53
Oxygen, . . .	15·61	15·63	15·76
	100·00	100·00	100·00

Results which correspond with the formula $C_{38}\,H_{21}\,NO_6$

	Mean.	Calculation.		
Carbon, .	72·91	73·31	C_{38}	228
Hydrogen, .	6·89	6·75	H_{21}	21
Nitrogen, .	4·53	4·50	N	14
Oxygen, .	15·67	15·44	O_6	48
	100·00	100·00		292

The mean of four closely agreeing analyses of this platinum compound gave the following results, which fully confirm this formula :—

	Mean.	Calculation.		
Carbon, .	44·09	44·06	C_{38}	228
Hydrogen,	4·46	4·25	H_{22}	22
Nitrogen,	2·71	2·70	N	14
Oxygen,		9·30	O_6	48
Chlorine,		20·59	Cl_3	106·5
Platinum,	18·90	19·08	Pt	98·7
		100·00		517·2

From these analyses the author concludes that there can be no doubt that the constitution of bebeerine is represented by the formula $C_{38}\,H_{21}\,NO_6$.

3. On the Vibrations of Plane-Polarised Light. By W. J. Macquorn Rankine, Esq.

If the plane of polarisation is normal to the direction of vibration, according to the conjecture of Fresnel, which seems to be supported by the phenomena of reflexion, the velocity of propagation of light in a crystalline medium is a function of the *direction of vibration.*

If, on the contrary, the plane of polarisation is parallel to the direction of vibration, the velocity of propagation is a function of the position of the *plane which includes the direction of vibration, and the direction of transmission.*

If the velocity of polarised light in a crystalline substance depends on the elasticity of the luminiferous medium alone, the latter view must be adopted, and Fresnel's supposition rejected; for a wave of light is a wave of distortion; and the rigidity, or elasticity which resists distortion, is, in all conceivable media, a function of the position of the plane of distortion, being the same for all directions of distortion in a given plane.

But the experiments of Mr Stokes on diffracted light (Cambr. Trans., Vol. ix., Part 1) prove that Fresnel's conjecture is correct, the plane of polarisation being normal to the direction of vibration: therefore the propagation of light in crystalline media does *not* depend on elasticity alone.

The author of this paper supposes, according to the hypothesis of molecular vortices (Trans. Roy. Soc. Edin., Vol. xx., Part 1), that the medium which transmits light and radiant heat consists of the *nuclei* of the atoms of matter, of very small mass, but exerting intense mutual forces, vibrating almost independently of the atmospheres which surround them. Each nucleus, however, carries along with it in its oscillations a small portion of atmosphere, which acts as a load, retarding the velocity of propagation. In the celestial space, this load is insensible, and it is, generally speaking, greater, the more dense the substance. In crystalline media, the atmosphere of each nucleus is distributed round it symmetrically with respect to three axes, but not equally in all directions; so that the load upon the nucleus, and consequently the velocity of propagation, is *a function of the direction of vibration,* as conjectured by Fresnel.

The author further shews, that according to this hypothesis, if the range of variation of the velocity of propagation of luminiferous transverse vibrations is small (as it is in all known media), that velocity must vary sensibly as the reciprocal of the diameter of an ellipsoid, drawn parallel to the direction of vibration. It is well known that this law is the foundation of the whole of Fresnel's theory of double refraction.

4. On the Mechanical Action of Heat. By W. J. Macquorn Rankine, Esq. Note as to the Dynamical Equivalent of Temperature in Liquid Water, and the Specific Heat of Atmospheric Air and Steam.

In the author's paper on the Mechanical Action of Heat (Trans. Roy. Soc. Edin., Vol. xx., Part 1), the calculations depending on the dynamical equivalent of temperature in liquid water were founded on the experiments of De la Roche and Bérard on the ratio of the apparent specific heat of atmospheric air under constant pressure to that of water. The equivalent thus obtained was about one-tenth part less than Mr Joule's. Since then, the author, having become acquainted with the details of Mr Joule's experiments, has come to the conclusion that Mr Joule's equivalent is correct to about $\frac{1}{300}$ of its amount, and that the discrepancy in question originates chiefly in the experiments of De la Roche and Bérard. The calculations requiring correction from this circumstance are contained in the second and third sections of the above-mentioned paper, articles 14 and 20, equations 28, 34, and 36. The following is a summary of the corrected results:—

Dynamical specific heat of liquid water, as determined by Mr Joule from experiments on friction (Phil. Trans., 1850)—

	Mètres.	Feet.
Per centigrade degree,	423·54	1389·6
Per degree of Fahrenheit,		772

Specific heat of atmospheric air, that of liquid water being taken as unity—

Real,	0·1717
Apparent, under constant pressure,	0·2404
(The same, according to De la Roche and Bérard,	0·2669)

Dynamical specific heat of steam—

	Mètres per Centig. degree.	Feet per Centig. degree.	Ft. per deg. of Fahr.
Real,	82·40	269·35	149·64
Apparent, under constant pressure,	129·18	422·83	235·46

Ratio of those two specific heats, 1 : 1·57.

Specific heats of steam, that of liquid water being taken as unity—

Real, 0·194 ; apparent, at constant pressure, 0·305.

The calculations and tables relative to the working of the steam-engine require no correction ; as the discrepancy in question has no effect on the computation of the action of the steam at full pressure, and no effect appreciable in practice on that of its expansive action.

The following Gentlemen were duly elected Ordinary Fellows :—

Dr R. D. THOMSON, Glasgow.
Dr MORTIMER GLOVER, Newcastle.

The following Donations to the Library were announced :—

Essai de Phytostatique appliqué à la Chaine du Jura et aux Contrées Voisines, par M. Thurmann. 2 Tom. 8vo.—*By the Author.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. IX., No. 26. ; Vol. X., Nos. 28 & 29. 8vo.—*By the Editors.*

Annals of the Lyceum of Natural History of New York. Vol. V., No. 1 ; Vol. IV., No. 12. 8vo.—*By the Lyceum.*

Journal of the Asiatic Society of Bengal. Edited by the Secretaries. Nos. 207 & 212. 8vo.—*By the Society.*

Memorie della R. Academia delle Scienze di Torino. Serie 2da, Tom. X. 4to.—*By the Academy.*

Journal of the Statistical Society of London. Vol. XIII., Part 2. 8vo.—*By the Society.*

Proceedings of the American Philosophical Society. Vol. V., No. 44. 8vo.—*By the Society.*

Proceedings of the Royal Society. 1849. Nos. 73 & 74. 8vo.—*By the Society.*

Memoirs of the American Academy of Arts and Sciences. N. S. Vol. IV., Part 1. 4to.—*By the Academy.*

Proceedings of the Royal Astronomical Society. Vol. X., No. 7. 8vo.—*By the Society.*

Q. Journal of the Chemical Society. No. 10. 8vo.—*By the Society.*

Report of the 19th Meeting of the British Association for the Advancement of Science. 1849. 8vo.—*By the Publisher.*

Scientific Researches, Experimental and Theoretical, in Electricity, Magnetism, Galvanism, Electro-Magnetism, and Electro-Chemistry. By William Sturgeon. 4to.—*By the Author.*

Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. Nos. 29 & 30, N. S. 1850. 8vo.—*By the Society.*

Astronomical, Magnetical, and Meteorological Observations made at the Royal Observatory, Greenwich. 1848. 4to.—*From the Observatory.*

Medico-Chirurgical Transactions, published by the Medico-Chirurgical Society of London. Vol. XXXIII. 8vo.—*By the Society.*

An Enquiry into M. Antoine d'Abadie's Journey to Kaffa, to discover the Source of the Nile. By C. T. Beke. 8vo.—*By the Author.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichenstalt. 1850. No. 1. Jan. Feb. Marz. 8vo.—*By the Institute.*

Philosophical Transactions of the Royal Society of London. 1850. Part 1. 4to.—*By the Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Wien. 1848–50. 8vo.—*By the Academy.*

Case of Catalepsy, with Remarks. By James Stark, M.D. 8vo.

Two Cases of Rupture of the Crucial Ligaments of the Knee-Joint. By James Stark, M.D. 8vo.—*By the Author.*

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XII., Part 2. 8vo.—*By the Society.*

La Thermacrose, ou la Coloration Calorifique, par M. Melloni. 8vo.—*By the Author.*

On the Pelorosaurus; an undescribed gigantic terrestrial reptile whose remains are associated with those of the Iguanodon, &c. On a Dorsal Dermal Spine of the Hylaeosaurus, recently discovered in the Strata of Tilgate Forest, Sussex. By G. A. Mantell, LL.D. 4to.—*By the Author.*

Supplementary Observations on the Structure of the Belemnite and Belemnostenthis. By G. A. Mantell, LL.D. 4to.—*By the Author.*

Quarterly Journal of the Chemical Society. Oct. 1850, No. 11. 8vo.—*By the Society.*

Collection of French Admiralty Charts.—*By the French Government.*

Proceedings of the Philosophical Society of Glasgow. 1849–50. Vol. III., No. 2. 8vo.—*By the Society.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1847, No. 3. 1848, Nos. 1 & 2. 8vo.—*By the Society.*

Flora Batava. Parts 163 and 164. 4to.—*By the King of Holland.*

Journal of the Royal Geographical Society of London. Vol. XX., Part 1. 8vo.—*By the Society.*

Bulletin de la Société de Géographie. 3me Serie. Tom. XIII. 8vo. —*By the Society.*

Gelehrte Anzeigen. herausg. von Mitgliedern der K. Bayerischen Akademie der Wissenschaften. Bde. 28 & 29. 4to.—*By the Academy.*

Det K. Danske Videnskab. Selskabs Skrifter. Femte Række. Naturvidenskabelig og Mathematisk Afdeling. 1te Bd. 4to.—*By the Society.*

Astronomical Observations made at the Royal Observatory, Edinburgh, by the late T. Henderson, Esq. Vol. IX. 1843. 4to.—*From the Observatory.*

Results of the Observations made by Rev. F. Fallows, at the R. Observatory, Cape of Good Hope, in the years 1829, 1830, 1831. Reduced under the superintendence of G. B. Airy, Esq. 4to.—*By the Editor.*

Abhandlungen über das Wesen der Imponderabilien, von L. Ph. Wüppermann. 1r Theil. 1e Abtheil. 8vo.—*By the Author.*

Abhandlungen der Philosophisch-Philologischen Classe der K. Bayerischen Akad. der Wissenschaften. Bd. 5. Abtheil. 3. 4to.

Abhandlungen der Mathematish-Physikalischen Classe der K. Bayerischen Akad. der Wissenschaften. Bd. 5. Abtheil. 3. 4to.—*By the Academy.*

Ueber den Antheil der Pharmacie an der Entwicklung der Chemie, von Dr Ludwig A. Buchner jun. 4to.—*By the Author.*

Archives du Muséum d'Histoire Naturelle. Tom. IV., Livraisons 3 & 4. 4to.—*By the Museum.*

Monday, 16*th December* 1850.

Sir D. BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read:—

1. Notice of a Roman Practitioner's Medicine Stamp, found near Tranent. By Professor Simpson.

At several of the stations throughout Western Europe that were formerly occupied by the colonists and soldiers of Rome, small engraved stones have been found, the inscriptions upon which shew them to have been used as medicine stamps by the Roman doctors who, many centuries ago, practised in these localities.

These medicine stones or stamps all agree in their general characters. They commonly consist of small quadrilateral or oblong pieces of a greenish-coloured steatite, engraved with a legend on one or more of their edges or borders. The inscriptions or legends are in small capital Roman letters, cut intagliate and retrograde, and consequently reading on the stone itself from right to left, but making an impression, when stamped upon wax or any other similarly plastic material, which reads from left to right.

The inscriptions themselves generally contain, and have engraved on each separate side, first the name of the medical practitioner to whom the stamp pertained, then the name of some special medicine or medical formula out of Galen, Scribonius Largus, or some of the more popular medical authorities of those times ; and, lastly, the name of the disease or diseases for which that medicine was prescribed.

In almost all, if not all, of the Roman medicine stamps hitherto discovered, the medicines mentioned on them are drugs for affections of the eye, and the diseases, when specified, are always ophthalmic diseases.

Above fifty such Roman medicine or oculist stamps have now been discovered on the continent of Europe, at stations occupied of old by the colonists and soldiers of Rome, and particularly in France, Germany, and Holland. Only two have been detected in Italy. About ten or twelve have been discovered among the old Roman sta-

tions in England. One was, some years ago, found amid a quantity of broken tiles, brick, and other debris of an old (and probably Roman) house near to the church of Tranent, and consequently not far from the old and extensive Roman town or station of Inveresk. This Roman medicine stamp, now deposited in the Scottish Antiquarian Museum, is remarkable both as being thus found on almost the very frontier of the ancient Roman Empire, and as being one of the most perfect yet discovered.

The stone is of the figure of a parallelogram about an inch and a-half in length, and a quarter of an inch in thickness, and with inscriptions cut upon two of its sides. The two inscriptions read as follows when we separate the individual words composing them from each other :—

1. L. VALLATINI EVODES AD CI-
CATRICES ET ASPRITUDIN

2. L. VALLATINI APALOCRO-
CODES AD DIATHESIS

When the elisions and contractions which exist in these (as in almost all other Roman inscriptions) are supplied, the two legends may be read as follows :—

1. *Lucii* VALLATINI EVODES AD CICATRICES ET ASP*e*RITUDIN*es*.—*The Evodes of Lucius Vallatinus for cicatrices and granulations.*

Several of the collyria described in the works of Galen, Celsus, Aetius, &c., and inscribed on the oculist-stamps, derived their designation from some special physical character. The present instance is an example in point, the appellation *Evodes* (εὐώδης) being derived from the pleasant odour (εὖ, well, and ὄζω, I smell) of the composition. Marcellus, in his work "De Medicamentis," specially praises the collyrium known under the name of *Evodes;* and that too in the class of eye diseases mentioned on the Tranent seal. For, in his collection of remedies for removing ulcers, cicatrices, &c., of the eyes and eyelids, he recommends (to use his own words) "præcipue hoc quod quidam Diasmyrnon, nonnulli *Evodes*, quia boni odoris est, nominant." And he directs the *Evodes* to be dissolved and diluted in water, and introduced into the eyes with a probe, or after inverting the eyelid, when it was used with the view of extenuating recent cicatrices of the eyes, and removing granulations of

the eyelids,— "ex aqua autem ad cicatrices recentes extenuendas, et palpebrarum asperitudinem tollendam teri debet, et subjecto specillo aut inversa palpebra, oculis inseri." *

Scribonius Largus had previously described, in nearly the same words, the collyrium,—" quod quidam εὐώδες vocant," and its uses in recent cicatrices and granulations, &c. Both these authors give the same recipe for the composition of the *Evodes*,—viz., pompholyx, burnt copper, saffron, myrrh, opium, and other ingredients, rubbed down in Chian wine. Its agreeable odour was probably owing to a considerable quantity of spikenard being used in its composition.† Galen gives two other collyria, of a different composition, and for other affections, as known at his time under the same name of *Evodes*,—the one termed the "*Evodes* of Zosimus," the other the "diasmyrnon *Evodes* of Syneros." ‡

2. L. VALLATINI APALOCROCODES AD DIATHESIS.—*The mild Crocodes of L. Vallatinus, for affections of the eyes.*

The term diathesis in this inscription is used in a different sense from that in which we now employ the same word in modern medicine. At the present day, we apply the term diathesis to designate the tendency or predisposition to some special disease, or class of diseases. In the times of the Roman physicians, it was often used as synonymous with disease itself; and in the Latin translations of the Greek texts of Galen, Aetius, &c., it is hence rendered usually by the general word "affectus," "affectio," &c. The first sentence in Paulus Ægineta's chapter on Ophthalmic Diseases, affords an instance in point: "Quum dolores vehementiores in oculis fiunt, considera ex quarum affectione (διαθεσει) oculum dolere contingit." § Thus, also, the *Evodes* of Zosimus (to which I have before alluded) is entered by Galen as a remedy simply against "dolores et recentes affectus," according to the Latin translation of Kuehn,—" προς περιωδυνιας και προσφατους διαθεσεις," according to the original Greek text. Galen uses in fact diathesis as a general term for eye diseases. "Scripsi

* Medicæ Artis Principes, p. 273.

† Medicæ Artis Principes: Scribonii Largi de Compositione Medicamentorum Liber. Comp. xxvi., p. 198.

‡ Galeni Opera Omnia. (Kuehn's Edit.) Vol. xii., p. 753 and 774.

§ Cornarius' Latin Translation in Principes Med. Artis, p. 432.

omnia quæ necesse est Medicum de oculorum affectibus (διαθέσεων) nosse." * In the inscription on the seal,—diathesIS stands instead of the common Roman accusative diathesES, or the Greek accusative diathesEIS.

The collyrium mentioned in the prescription (the *Crocodes*) derives its designation from its containing the crocus, or saffron, as one of its principal ingredients.

In describing the therapeutic effects of the crocus, Dioscorides mentions as its first special use—its efficacy in "fluxions of the eyes."†

Pliny, in enumerating the qualities of the crocus, begins by observing, that it has a discutient effect upon all inflammations, but chiefly on those of the eyes (discutit inflammationes omnes quidem, sed oculorum maxime); and in speaking of its combinations he tells us that it has given a name to one collyrium (collyrio uno etiam nomen dedit).‡ But it entered into the composition of very many of the ancient eye medicines, and more than one of these passed under the name of *Crocodes*, as in the inscription on the seal. Galen, in his list of eye remedies, gives a recipe for the composition of a *Crocodes* collyrium for epiphoræ, pains and affections (διαθέσεις) from wounds of the eye.§ He discusses the composition also of the aromatic *Crocodes* of Heraclides, and the oxydercic *Crocodes* of Asclepius, &c.‖ When describing, in another part, the remedies for ulcers of the eyes, he mentions a collyrium containing crocus, and adds, "habet autem plurimum in se crocum, unde etiam croceum (κροκωδες) appellatur."¶

Celsus, Alexander Trallianus, and Paulus Ægineta, give recipes for eye collyria, under the name of diacrocus (δια κροκος).**

We have not yet alluded to the expression APALO, standing before *Crocodes*. This expression presents the only difficulty in reading

* Kuehn's Edit. of Galen, xii., p. 699.

† P. Dioscoridis Opera quæ extant Omnia. (Edit. Saraceni., 1698.) P. 21, lib. i., cap. xxv.

‡ Naturalis Historia. Leyden edit. of 1635. Vol. ii., p. 473.

§ Opera a Kuehn. Tom. xii., p. 770.

‖ Ibid. Pp. 785 and 773.

¶ Ibid. P. 713.

** See Milligen's Celsus, p. 295; Principes Artis Medicæ, p. 170 of Part II. and p. 432 of Part III. Our own Pharmacopœias long retained similar terms. The London Pharmacopœia, for example, for 1662, contains an electuary termed Diacrocuma, an emplastrum Oxycrocum, &c.

the inscription; and various suggestions might be offered in regard to its explanation. But it seems most probable that it was used as a qualifying term to the *Crocodes*. Several of the collyria have the Latin adjective "lene," and "leve," placed before them, in order to certify their mild nature. Scribonius Largus gives a whole division of collyria, headed "Collyria composita levia." Aetius has a chapter, "De Lenibus Collyriis." The expression *apalo*, as a part and prefix to *Crocodes*, would seem to indicate the same quality in the crocodes vended, of old, to the Roman colonists and inhabitants of the Lothians, by Vallatinus of Tranent, the term being in all likelihood derived from the Greek adjective *απαλος*, or the corresponding Latin adjective *apalus* (mild, soft). Homer frequently uses the word as signifying soft, delicate, and especially as applied to different parts of the body (See Iliad, book iii. 371; xvii. 123, &c.); and, indeed, both Aetius and Paulus Ægineta employ the Greek adjective therapeutically in the sense of mild, and as applied to collyria. In the treatment of acute inflammatory ulcers of the eye, after inculcating the usual antiphlogistic treatment, Aetius adds, "collyria vero tenera (*απαλα*) ulcerato oculo infundantur."* When speaking of carbuncles and carcinoma of the eye, Paulus Ægineta observes that the affection may be alleviated "by the injection of soothing (tenera, *απαλα*) collyria, such as the Spodiacum, Severianum, and the like."†

Other Roman medicine stamps with analogous oculist legends and collyria have, in England, been found at Colchester, Bath, Wroxeter, Cirencester, Kenchester, Littleborough, St Albans, &c. &c.

2. Astronomical Notices. By Professor C. Piazzi Smyth.

These Notices were chiefly derived from the ordinary correspondence of the Royal Observatory of Edinburgh, from the important character of some of which Professor P. Smyth hoped that extracts from the best of the letters might be of interest to the Society.

He alluded first to the astronomers of the United States, a large and increasing body, of no mean order of excellence already, and of the richest promise. Professor Loomis' recent work, which was exhibited, gives sufficient facts to prove the above statements.

---

* Cornarius' Latin edit. of Aetius, 1549, p. 371; and Venice Greek edit., p. 126.

† Dr Adams' Sydenham Society edition, Vol. i., p. 419; and the Basle Greek edition, p. 76.

Dr Locke's pamphlet on his electric observing clock was also shewn; and mention was made of the discovery of the third ring of Saturn, a faint ring interior to the older ones, about one-fourth of their united breadth, but apparently thicker.

The period of the new Bond and Lassel satellite of Saturn, Hyperion, was given at 21·18 sidereal days.

Attention was called to a map of the solar eclipse of July 28, 1851, sent from the Vienna Observatory, and the great importance of having the phenomenon extensively observed was pointed out.*

The periods of the new planets, Victoria and Egeria, were given, as well as their places for the month, together with that of Faye's comet, expected on its return to perihelion.

The successful manufacture of telescopes in this country, especially of reflecting ones, was then spoken of, and the attempt that had been made, but unhappily without success, by some scientific societies and private individuals to persuade Government to establish one of these instruments in some more favourable climate than that of the British Islands.

It appears that we can make at home far better reflectors than any other nation, but cannot use them on account of clouds; but we possess colonies nearer the equator with almost cloudless skies, and with high mountains, or table lands, on which the telescopes might be raised above all the grosser part of the atmosphere, and some of our astronomers are most anxious to go out in charge of such instruments, confident of the rich results which they must yield under such favourable circumstances,—but yet the Government refuses to do anything.

3. Farther Observations on Glaciers,—(1.) Observations on the Movement of the Mer de Glace down to 1850. (2.) Observations by Balmat, in continuation of those detailed in the Fourteenth Letter. (3.) On the gradual passage of Ice into the Fluid State. By Professor J. D. Forbes.

"It will be recollected that a remarkable stone called 'La pierre platte,' was one of the earliest points on the Mer de Glace at Cha-

* The line of central obscuration passes nearly through the cities of Gottenburg and Dantzic, and both are included within the limits of complete eclipse.

mouni whose position was ascertained by me in 1842. Its daily motion was watched by me during that summer, and its annual motion was ascertained by renewed observations in 1843, 1844, 1846, and again this year. I measured the distance along the ice from the original position of the 'Pierre platte' on the 27th June 1842 (ascertained by reference to fixed marks on the rocks) to its position on the 12th July 1850, and found it to be 2520 feet. But, of this distance, 1212 feet had been travelled at my previous observation on the 21st July 1846, leaving 1308 feet during the last four years against 1212 in the first four. When more accurately stated and compared, the mean annual and daily motions will stand as follows :—

	1842–3.	1843–4.	1844–6.	1846–50.
Daily motion, in INCHES,	9·47	8·56	10·65	10·81
Annual motion, in FEET,	288·3	260·4	323·8	328·8

We cannot infer, with absolute certainty, that the slight increase of velocity here noticed since 1844 is due to a change in the conditions of the glacier (although I believe that the recurrence of several snowy seasons and the very marked increase of the volume and extent of the glacier during these years would produce such an effect), because it has moved nearly half-a-mile from its position when first observed, and the part of the glacier on which it now lies may be subject to different accelerating and retarding causes.

" It is mentioned in my Thirteenth Letter on Glaciers in Professor Jameson's Journal, that I marked a fine solitary block towards the centre of the Mer de Glace opposite 'Les Ponts' with the letter V in 1846, and that I took angles for fixing its place with reference to the adjacent rocks. It was then about 760 feet distant from the west bank. I had little difficulty in recognizing the block in 1850, although it had travelled a great distance, and was considerably lower than the Montauvert. It had preserved its parallelism to the shore, for I found it at almost the same distance from the west bank as at first; and by measuring carefully along the side of the glacier, I estimated its progress in four years, from 30th July 1846 to 13th July 1850, at 3255 feet. This gives, for the mean motion in 365 days, 822·8 feet, or the mean daily motion 27·05 inches, which is remarkably large. Its position is very near the point of one of the

'dirt-bands,' but a little nearer the western bank. It lies, however, *on* the band.

"I shall now give the sequel of my guide Auguste Balmat's observations on the motion of the Glacier des Bois (the outlet of the Mer de Glace), and of the Glacier des Bossons, since the period to which the table in my Fourteenth Letter extends, which will be found to embrace *continuous* observations, by periods of a few weeks from the 2d October 1844 to the 21st November 1845. They were continued in like manner until the 19th February 1846, when they were interrupted by Balmat's illness, which was accompanied by inflammation of the eyes. But in October of the same year they were resumed, and were continued without intermission until the end of June 1848, embracing altogether a period of nearly four years, with only eight months' intermission. It is necessary to observe that the station on the glacier of Bossons was altogether changed after the above mentioned interruption, being transferred from the west to the east side (in the same region of the glacier), and it was 340 feet from the bank. The station on the Glacier des Bois was almost unchanged, and was about 280 feet from the north bank, between the Côte du Piget and the acclivity of the Chapeau. I have added a column giving the mean of the temperatures of the several periods of observation, carefully calculated from the published observations at Geneva and the great St Bernard, on the same principle as I have fully explained in my Fourteenth Letter above referred to. The comparisons of the temperature and the rate of motion lead to conclusions similar to those which I have drawn in that paper from the earlier observations, the general observation always holding that the acceleration in spring is in a greater proportion to the temperature than at any other season of the year, on account of the great influence of the melting snows in imparting fluidity to the glacier masses. I do not mean that the comparison leads always to consistent results. I do not think that the causes of the comparative acceleration of one glacier and retardation of another have yet been clearly brought out, though I conceive that accurate local observations, combined with such measurements, would gradually but surely unveil them. Nor do I mean to affirm that measurements made with so much labour and trouble, and under circumstances even of personal danger at certain seasons of the year, are irreproachable in point of accuracy. I think it even probable that oversights have occurred; but I have

very strong reason for confiding in the absolute fidelity with which the observations have been made and transmitted to me.

TABLE shewing the mean daily motion in inches of the Glaciers of Chamouni deduced from Balmat's Observations, and continued from the Fourteenth Letter.

Intervals of Observation.	Mean Daily Motion in Eng. inches.				Temp. Centigrade of Air.*	Remarks.
	Bois, No. I.	Bois, No. II.	Bossons, No. I.	Bossons, No. II.		
1845. Nov. 16 to Dec. 16	14·0	10·9	west side 30·2	6·4	−1·47	
Dec. 16 to Jan. 19	12·0	5·7	18·8	10·0	−4·19	
1846. Jan. 19 to Feb. 19	16·1	5·1	16·9	13·0	−0·16	
(Observations interrupted by Balmat's illness.)						
Oct. 12 to Nov. 19	21·8		east side. 10·8		1·65	16th Oct. Snow at Montanvert.
Nov. 19 to Dec. 20	24·0		13·1		−4·41	
Dec. 20 to Jan. 18	24·5		12·8		−5·88	
1847. Jan. 18 to Mar. 4	31·5		14·5		−4·82	Vast quantity of snow. Destructive avalanches.
Mar. 4 to Apr. 12	34·5		13·9		−1·08	
Apr. 12 to May 14	37·3		19·7		3·10	
May 14 to July 2	34·2		22·6		9·97	Snow disappeared on Bossons, 2d. week of May: on Bois, 3d week of May.
July 2 to July 23	30·5		23·1		13·88	
July 23 to Aug. 16	34·0		25·8		11·89	
Aug. 16 to Sept. 9	44·7		23·5		9 65	
Sept. 9 to Sept. 28	37·7		22·6		7·95	
Sept. 28 to Oct. 18	32·2		21·5		5·34	
Oct. 18 to Nov. 6	30·7		14·5		3·41	
Nov. 6 to Nov. 27	30·2		10·7		0·24	
Nov. 27 to Jan. 10	24·4		10·5		−3·74	
1848. Jan. 10 to Feb. 19	26·5		14·5		−5·79	
Feb. 19 to Apr. 1	23·5		12·6		−0·64	
Apr. 1 to May 3	33·8		18·8		4·93	
May 3 to June 6	35·3		17·6		8·68	
June 6 to June 30	43·8		17·6		11·57	

"I have formerly taken occasion to mention experiments and observations which have occurred from time to time of a nature to confirm the fundamental hypothesis of the *quasi* fluidity of the ice of glaciers on the great scale, and I cannot doubt that these incidental remarks have tended to diminish the natural incredulity with which that theory was at first received in some quarters. I have now to cite a fact of the same kind established by a French experimenter, M. Person, who appears not to have had even remotely in his mind

* Mean of Geneva and Great St Bernard.

the theory of glaciers when he announced the following fact, viz. :—That ice does not pass *abruptly* from the solid to the fluid state. That it begins to *soften* at a temperature of 2° centigrade below its thawing point: that, consequently between 28·°4 and 32° of Fahrenheit, ice is actually passing through various degrees of plasticity, within narrower limits, but in the same manner that wax, for example, softens before it melts. M. Person deduces this from the examination of the heat requisite to liquify ice at different temperatures. The following sentences contain his conclusions in his own words :—" Il parait d'après mes experiences que le ramollissement qui précède la fusion, est circonscrit dans une intervalle d'environ 2 degrés. La glace est donc un des corps dont la fusion est la plus nette; mais cépendant le passage de l'état solide à l'état liquide s'y fait encore par degrés, et non par un saut brusque."*

" Now it appears very clearly from M. Agassiz' thermometrical experiments, and from my own observations, that from 28° to 32° Fahr. is the habitual temperature of the great mass of a glacier; that the most rigorous nights propagate an intense cold to but a very small depth ; and I am perfectly convinced that in the middle and lower regions of glaciers which are habitually saturated with water in summer, the interior is little, if at all, reduced below tho freezing point, even by the prolonged cold of winter; it would be contrary to all just theories of the propagation of heat if it were otherwise, when we recollect that the enormous mass of snow which such glaciers bear during the coldest months of the year, is a covering sufficient to prevent any profound congelation in common earth ; and admitting that ice is probably a better conductor of heat than the ground, it is quite incredible that a thickness of many hundred feet of ice, saturated with fluid water, should be reduced much below the freezing point, or should even be frozen throughout.

" It thus appears quite certain that ice, under the circumstances in which we find it in the great bulk of glaciers, is in a state more or less *softened* even in winter; and that, during nearly the whole summer, whilst surrounded by air above 32°, and itself at that temperature, it has acquired a still greater degree of plasticity, due to the latent heat which it has then absorbed.

" I have mentioned that the observations of this and some previous

* Comptes Rendus, 29th April 1850.

summers have enabled me to extend the survey of the valley of Chamouni beyond the limits to which my Map was originally confined. I have also obtained a great number of approximate altitudes of all the highest summits of the chain of Mont Blanc, from the extended base which the distance from the Mont Breven to the Croix de Flégère (above 15,400 feet) has afforded me. But the results are as yet only partially calculated. I have also made some additions to our knowledge of the geography of the eastern part of the chain of Mont Blanc, by examining the Glacier of La Tour in its whole extent, which proved the configuration of the mountains to be different from what has been represented on all the maps and models which I have seen. The Glaciers of Argentière and La Tour are separated throughout by a rocky ridge, but the Glaciers of La Tour and Trient all but unite at their highest parts, and the main chain is prolonged with scarcely a break in the north-east direction, sending off only a spur towards the Col de Balme, which, perhaps from being the political boundary of Savoy and Switzerland, has been represented generally on an exaggerated scale. What surprised me most, was the great elevation of the axis of the chain at the head of the Glaciers of La Tour and Trient. I found it barometrically to be 4044 feet above the châlet of the Col de Balme, which, from five comparisons made with the observatory at Geneva, is 7291 English feet, or 2220 mètres above the sea, a result agreeing closely with the recent measurement by M. Favre, which is 2222 mètres. Adding this result to the former, we obtain 11,335 English feet for the height of the granitic axis at the lowest point between the Glaciers of La Tour and Salena on the side of the Swiss Val Ferret. By a single direct barometrical comparison with Geneva, I obtained 11,284 English feet above the sea, or 140 feet higher than the Col du Géant. I was successful in traversing the Glacier of Salena to Orsières the same day, a pass which has not before been described, and which has this interest, in addition to the singular wildness of the scenery, that it includes those regions of beautiful crystallized protogine, here *in situ*, which have been known to geologists hitherto chiefly from the numerous moraines which they form in the valleys of Ferret and of the Rhone, and especially the majority of the blocks of Monthey, which have been derived, according to M. de Buch, entirely from this region of the Alps."

Professor Forbes then gave a verbal notice of Dr Faraday's recent investigations on the Magnetism of Oxygen Gas and of the Atmosphere, including his views on the Diurnal Variation of the Needle.

Dr Spittal

Was balloted for, and duly re-elected a Fellow of the Society.

The following Gentlemen were duly elected Ordinary Fellows:—

Beriah Botfield, Esq., F.R.S., Norton Hall, Northamptonshire.
Dr James Scarth Combe.

The following Donations to the Library were announced:—

Journal of the Statistical Society of London. Vol. XIII., Pt. 3. 8vo.—*By the Society.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Diet. 5 & 6. 4to.—*By the Society.*

Astronomische Beobachtungen auf der K. Universitäts Sternwarte in Königsberg. Herausg. Von A. L. Busch. Abtheil. 29. fol.—*By the Observatory.*

Observations made at the Magnetical and Meteorological Observatory at Hobarton, in Van Diemen Island, and by the Antarctic Naval Expedition. Vol. I. 1841. 4to.—*By the Observatory.*

Proceedings of the American Philosophical Society. Vol. V., No. 44. 8vo.—*By the Society.*

Proceedings of the Zoological Society of London. Nos. 178–189. 8vo.—*By the Society.*

Proceedings of the Royal Society. Nos. 73 & 74. 8vo.—*By the Society.*

Seventeenth Annual Report of the Royal Cornwall Polytechnic Society. 1849. 8vo.—*By the Society.*

Journal of the Asiatic Society of Bengal. N. S. No. 37. 8vo.—*By the Society.*

Letter to the Rt. Hon. Lord Brougham and Vaux, containing proposals for a scientific exploration of Egypt and Ethiopia. By John James Wild. 8vo.—*By the Author.*

The Accommodation of the Eye to Distances. By William Clay Wallace, M.D. 8vo.—*By the Author.*

Oversigt over det Kgl. Dánske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider i Aarets 1847 og 1848. 8vo.—*By the Society.*

Verhandelingen der Eerste Klasse van het K. Nederlandsche Instituut, &c. 3de Reeks. II. & IIIe Deel. 4to.

Jaarboek van het K. Nederlandsche Instituut, &c. Voor 1850. 8vo.

Tijdschrift voor de Wis-En Natuurkundige Wetenschappen, uitgegeven door de 1ste Klasse van het K. Nederlandsche Instituut. 3de Deel. 4e Aflevering. 8vo.—*By the Institute.*

Kongl. Vetenskaps Akademiens Handlingar under Sednare Hälften. 1848. 8vo.

Öfversigt af K. Vetenskaps-Akademiens Förhandlingar. 1849. Nres 1–9. 8vo.

Arsberättelse om Framstegen i Kemi under är 1848. Afgifeu till K. Vetenskaps-Akademien af L. F. Svanberg. 8vo.

Medallion of Berzelius.—*By the Academy.*

Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. Sciences Mathématiques, Physiques et Naturelles. Tomes 7me & 8me. 4to.

Mémoires présentés à l'Acad. Imp. des Sciences de St Pétersbourg. Tome 6me. Livraison 4me. 4to.

Recueil des Actes des Séances publiques de l'Acad. Imp. des Sciences de St Pétersbourg, tenues le 28 Decembre 1847 et le 29 Decembre 1848. 4to.—*By the Academy.*

Explication de la Carte Géologique de la France, rédigée par MM. Dufrénoy et Elie de Beaumont. Tomes 1 & 2. 4to.—*By the French Government.*

Geological Map of France.—*By the Same.*

Monday, 6th January 1851.

Sir D. BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read :—

1. Notice of a Tertiary Fossiliferous Deposit, underlying Basalt, on the Island of Mull. By the Duke of Argyll.

This paper, in its perfect form, appears in the Transactions

of the Geological Society. The abstract read by His Grace on this occasion was illustrated by a number of drawings and specimens.

The order of beds shewn in the drawings, from above downwards, was as follows :—

1. A bed of basalt, rudely columnar.
2. A bed containing impressions of leaves of dicotyledonous trees.
3. A bed of tuff, or trap conglomerate, having the aspect of volcanic ashes.
4. A bed of leaves similar to No. 2.
5. A bed of tuff similar to No. 3.
6. A third bed of leaves similar to the two former.
7. A bed of amorphous basalt ending in basalt highly columnar.

2. Analysis of the Mineral Waters of Baden Baden. By Dr Sheridan Muspratt.

The author, after mentioning that no analysis of this water is to be found in any English work, and the great multitudes who resort to it, described briefly the situation of the Ursprung or original spring, the chief one at Baden, which was known to, and esteemed by, the Romans.

It has a temperature of 153·5° F., and contains, in the imperial gallon, 181·120 grains of solid matter. The predominating ingredient is chloride of sodium or common salt, which amounts to 132·6 grains in the gallon. Next to this comes carbonate of lime, dissolved no doubt as bicarbonate, which is deposited as carbonate on boiling. The other ingredients, which are in trifling quantity, are detailed in the first table given below as obtained in the analysis. In the second, they are arranged in the order of their probable occurrence in the water.

TABLE I.

	Grains per Imperial Gallon.	
Sulphuric acid, ...	3·487	3·495
Chlorine, ...	94·064	95·991
Silicic acid, ...	2·947	
Carbonic acid in combination with lime, .	6·240	
Do. in combination with protoxide of iron,	·514	
Sodium, ...	52·152	
Potassium, ...	7·182	
Calcium, ...	4·000	
Lime (insoluble), ...	7·943	
Magnesia, ...	1·749	
Protoxide of iron, ...	·842	
Alumina, . . . / Phosphate of lime, / Organic matter, ...	mere traces.	
	181·120	

TABLE II.

Statement of the constituents as existing in the water :—

	Grains per Imp. Gallon.
Chloride of sodium, ...	132·644
Chloride of potassium, ...	13·720
Chloride of calcium, ...	11·040
Carbonate of lime, ...	14·184
Silicic acid, ...	2·947
Proto-carbonate of iron, ...	1·556
Alumina, . . . / Phosphate of lime, / Organic matter, ...	mere traces.
	181·127

Monday, 20*th January* 1851.

Dr CHRISTISON, Vice-President, in the Chair.

Some notices were given, by the Rev. J. Hannah, of an elaborate paper received, through Professor Jameson, from Mr J. R. Logan of Singapore. The following is the Author's own account of its nature and contents:—

1. Traces of an Ethnic Connection between the Basin of the Ganges and the Indian Archipelago, before the Advance of the Hindus into India; and a Comparison of the Languages of the Indo-Pacific Islanders with the Tibeto-Indian, Tibeto-Burmese, Telugu-Tamulian, Tartar-Japanese, and American Languages.

I.—*Preliminary Enquiries.*

§ 1. Principal continental connections of the Archaic ethnology of Asianesia.
§ 2. Physiological and moral evidence of an Indian connection.
§ 3. General ethnic principles and tendencies observable in the ethnology of Eastern Asia and Asianesia.
a. Mutual physiological and moral action of tribes.
b. Linguistic development and mutual action of tribes.
§ 4. Character of primordial phonology. Remnants of it in S. E. Asia.
§ 5. Cause of the transition from the monotonic to dissyllabic glossaries.
§ 6. Comparative value of structural and glossarial comparisons for ethnology. Superiority of the glossarial. Supreme importance of Phonology.

II.—*Phonetic and structural character of the archaic languages of India.*

§ 7. Prepositional and postpositional languages.
§ 8. Character of the Tibetan and Burmese with relation to each other and to the Tartarian and S. E. Asian languages.
§ 9. The N. Gangetic or Himalayan languages.
§ 10. The S. E. Gangetic languages.
§ 11. The S. Gangetic languages.
§ 12. The Telugu-Tamulian languages.
§ 13. Comparison of the Telugu-Tamulian with the African languages.

III.—*Phonetic and structural character of the Asianesian languages.*

§ 14. Australian.
§ 15. Polynesian.
§ 15,* Papuanesian.
§ 16. S. and S. E. Indonesian.
§ 17. N. E. Indonesian.
§ 18. W. Indonesian.

IV.—*The Asianesian languages compared with the American and Tartar-Japanese languages.*

§ 19.* Asianesian compared with American languages.
§ 20.* The Asianesian compared with the Japanese, Korian, and Tungusian languages.
Sub sect. 1. Japanese.
— 2. Korian.
— 3. Manchu.
— 4. Results.

V.—*Ethnic Glossology.*

§ 19. Principles of glossarial comparison.
§ 20. Character of Asianesian glossology.
§ 21. Permutations of sounds.
§ 22. Comparison of Definite, Segregative, and Generic words or particles.
§ 23. Pronouns.
§ 24. Numerals.
§ 25. Names of parts of the body.
§ 26. Names of domesticated animals.
§ 27. Miscellaneous words.

Conclusion.

Several lengthy extracts were read, to illustrate, *first*, the relation which the author's historical views bear to those of previous inquirers in the same field; and, *secondly*, the theory, on the origin and progress of language, upon which his arguments are mainly rested.

2. The following Note was read on the recent frequent occurrence of the Lunar Rainbow, by George Buchanan, Esq.

The frequent occurrence of this phenomenon lately suggests the idea, whether it be any way connected with the relation of the atmosphere to an electric or other condition.

On Thursday evening last, at 7 o'clock, I observed a very beautiful rainbow, from Duke Street, extending in a brilliant and unbroken arch in a westerly direction; the south end springing from the west end of Queen Street, and the north end stretching to the eastern extremity of Abercromby Place, comprising a space in the horizon of 60° or 70°, and rising 16° or 18° in altitude.

The prevailing colour was whitish, but occasionally the prismatic colours shone out very distinctly, particularly the *red* and the *blue.*

The weather was squally, with showers, and the bow appeared for at least half an hour.

Last night (Sunday evening) the same appearance was seen with beautiful effect at 11 P.M., and continued for upwards of half an hour.

The following Donations to the Library were announced:—

Proceedings of the Academy of Natural Science of Philadelphia. Vol. V., No. 5. 8vo.—*From the Academy.*

The American Journal of Science and Arts. 2d Ser., No. 30. 8vo.—*From the Editors.*

Proceedings of the Royal Astronomical Society of London. Vol. II., No. 2. 8vo.—*From the Society.*

Résumé Météorologique de l'Année 1849, pour Genève et le Grand St Bernard, par E. Plantamour. 8vo.—*From the Author.*

Reasons for returning the Gold Medal of the Geographical Society of France, and of withdrawing from its membership. In a Letter to M. De la Roquette, from Charles T. Beke. 8vo.—*From the Author.*

Astronomical and Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1849. 4to.

Greenwich Magnetical and Meteorological Results. 1848. 4to.—*From the Observatory.*

Astronomical Observations made at the Observatory of Cambridge. Vol. XVI., 4to.—*From the Observatory.*

Transactions of the Cambridge Philosophical Society. Vol. IX., Part. 1. 4to.—*From the Society.*

Monday, 3d February 1851.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read :—

1. On some new Marine Animals, discovered during a cruise among the Hebrides with Robert Macandrew, Esq., of Liverpool, in 1850. By Professors Edward Forbes and J. Goodsir. Communicated by Professor Goodsir.

The animals either wholly new, or new to Britain, described in this communication, were taken during a yachting cruise with Mr Macandrew, of Liverpool, among the Hebrides, in the month of August 1850. During this voyage, which lasted three weeks, a series of observations were conducted by means of the dredge and towing-net. Not a single new testaceous Mollusk was procured; but several remarkable Ascidians and Radiata were discovered, some of them so curious in themselves, and so important in their zoological bearings, that the authors of this paper thought it desirable to lay an account of them before the Royal Society of Edinburgh.

The most remarkable of these is the longest compound Ascidian yet discovered in the Atlantic. Its nearest described ally is the genus *Diazona* of Savigny, between which animal and *Clavellina* it forms a link. The authors of this paper propose to designate this animal *Syntethys Hebridia*, having found it necessary to establish a genus for its reception. The authors have also dredged up the *Holothuria intestinalis* of Ascanius and Rathke, which is the second species of *Holothuria* proper discovered in the British seas; the first having being discovered by Mr Peach under the name of "Nigger," given to it by the Cornish fishermen.

A new species of the curious genus *Sarcodictyon*, distinguished by the polype cells being grouped in assemblages of from three to five, was described under the designation of *S. agglomeratum*.

The *Arachnactis albida* of Sars was found in the Minch. Portions of an animal found by Professor Balfour in the same locality in 1841, have now been recognised as belonging to this curious Actinea.

The other animals described in this communication were, a species of naked-eyed Medusa, for the reception of which the authors found it necessary to establish a new genus, *Plancia* (*Plancia gracilis.*) Seven new species of Medusæ, referable to the genera *Oceanea*, *Slabberia*, *Hippocrene*, and *Thaumantias*, were also described.

The communication was illustrated by coloured drawings.

2. Account of Experiments on the Thermotic Effect of the Compression of Air, with some practical applications. By Professor C. Piazzi Smyth.

3. Theoretical investigations into the same by W. Petrie, Esq. Communicated by Professor C. Piazzi Smyth.

Having brought before this Society in April 1849, a plan for cooling the air of rooms in tropical climates, the author was anxious to determine by actual experiment on a very large scale the practicability of the principle involved, viz., the thermotic effect of the compression of air. He had had a small apparatus made in 1844, which, though not sufficiently large to give exact numerical data, at least showed that the plan was in the bounds of possibility.

But in December 1849, Mr Wilson, of the Kinniel Ironworks, having kindly allowed him to experiment on the compressed air in the reservoir tubes of the furnaces, Professor P. S. proceeded there in company with Mr Stirling, C.E., and Capt. Gosset, R.E., with an apparatus which was exhibited on the table.

Thirty-four different experiments were made, in as varied a way as possible to insure accuracy, and the mean result was, that the air being at 63° Fahr., and the barometer at 30· inches, and the pressure guage indicating 7·2 inches of mercury, the rise of temperature of the air on being made to enter the compression-chest, was 28°·9, and the fall on escaping therefrom was 26°·9.

Professor W. Thomson, from Carnot's theory of heat, and Mr Macquorn Rankine from his own, deduced nearly the same quantity, but with some uncertainty, as the specific heat of air was involved.

Mr Petrie, however, without taking up any theory of heat, but merely the mechanical nature of a compressible fluid, and the well known quantity of the expansion of air from heat, deduced a formula which represented the above observations as well as could be expected. And pursuing his formula to its ultimate consequences, he

arrived at the interesting result, that beginning with air at 60° Fahr., unlimited *expansion* would only lower it 550°; while by sufficiently increasing the *compression*, an infinite degree of heat could be produced.

The practical result of the experiments and conclusions from theory was to make the proposed method of cooling the air of rooms (viz., by compressing the air, depriving it when compressed of its extra heat, and then allowing it to escape into the room to be cooled),—very possible indeed.

While, to get over the difficulty that might be experienced in the colonies of managing the air pumps and coolers which would be required according to Professor P. S.'s plan, Mr Petrie proposed some simple forms of water-pressure machines, and air-compressing wheels.

The following Gentleman was duly elected an Ordinary Fellow:—

Sir DAVID DUNDAS, Bart., of Duneira.

The following Donations to the Library were announced:—

Proceedings of the Royal Astronomical Society of London. Vol. II., No. 1. 8vo.—*By the Society.*

On the Cyclone of November 19 (1850). By the Rev. Humphrey Lloyd, D.D. 8vo.

On the Induction of Soft Iron, as applied to the determination of the changes of the Earth's Magnetic force. By the Rev. Humphrey Lloyd, D.D. 8vo.—*By the Author.*

Instructions for Making Meteorological and Tidal Observations. Prepared by the Council of the Royal Irish Academy. 8vo.

Second Report of the Council of the Royal Irish Academy, relative to the establishment of a System of Meteorological and Tidal Observations in Ireland. 8vo.—*By the Academy.*

The London University Calendar. 1851. 12mo.—*By the Publishers.*

Monday, February 17, 1851.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. Biographical Notice of the late Robert Stevenson, Esq., Civil Engineer. By his Son, Alan Stevenson, L.L.B. Communicated by Dr T. S. Traill.

This memoir commences by stating that Mr Stevenson was born at Glasgow on the 5th May 1772, and that he died at Edinburgh, in the seventy-ninth year of his age, on the 12th July 1850. The writer then notices the disadvantages under which Mr Stevenson laboured in infancy and youth, owing to the death of his father, who was a partner in a West India House in Glasgow, and died in the Island of St Christophers soon after the birth of his only child. In spite of these, and by the prudence and energy of his mother, Robert Stevenson had the benefit of a tolerably full course of training both in science and literature, first at the Andersonian Institution in Glasgow, and afterwards at the University of Edinburgh; and so great was his zeal in the pursuit of knowledge, that, while acting during the summer as a superintendent of works, under Mr Smith, the engineer of the Lighthouse Board, his future father-in-law, he regularly devoted the winter months to the study of mathematics, natural philosophy, chemistry, and architectural drawing. Some pretty long extracts from some MSS. memoranda, left by Mr Stevenson himself, and from his "Account of the Bell Rock Lighthouse," next follows; and in them an interesting view is given of his early designs for the Bell Rock Lighthouse, and of the difficulties with which he had to contend, and the encouragements he met with in reference to his great enterprise. The writer then goes on very briefly to notice his father's long service of about forty years as engineer to the Commissioners of the Northern Lighthouses, in which office he succeeded his father-in-law, Mr Smith, in 1806. During that period, he was the architect of no fewer than

twenty-three lighthouses, including that of the Bell Rock; and through his indefatigable zeal and patient skill, the catoptric system of lighthouse illumination was in Scotland brought to a state of perfection which has not elsewhere been equalled. Many of those improvements he was the means of extending to the lighthouses of Ireland and of some of the colonies. He also invented two valuable additions to the mode of distinguishing lights on a coast, known as the *intermittent* and *flashing* lights, the latter of which, in particular, has been generally approved by seamen; and so much was the late King of the Netherlands pleased with the arrangement and effect of this distinction, of which he had read an account, that he sent to Mr Stevenson a gold medal as a mark of his approbation. The memoir next notices Mr Stevenson's career as a practitioner in his profession of a civil engineer, in the course of which it is not perhaps generally known that he designed and executed the eastern approach to Edinburgh by the Calton Hill; and, after alluding to several of his works in bridges and harbours, it mentions his improvements in the construction of timber and suspension bridges, and notices his connection with the first introduction of the railway system into Great Britain, and his contributions to various scientific journals, and to literature of his own profession. In conclusion, the writer briefly touches upon the private character of his father, and the esteem in which he was held by all who knew him, and more especially by the Commissioners of the Northern Lighthouses, who, in 1824, ordered his bust to be placed in the Bell Rock Lighthouse, and, on the occasion of his death, recorded in the Minutes of the Board their respect for his talents as a public officer and his virtues as a man.

2. Historical Notice of the Progress of the Ordnance Survey in Scotland. By Alexander Keith Johnston, Esq.

There are few places on the earth's surface which, within such a limited area, combine so many of the requisite elements for chartographic delineation as are met with in Scotland. With mountains rising almost to the limit of the snow-line, and an extensive sea-

board, broken up by firths and lochs into every conceivable form of promontory, cape, and headland, this portion of Great Britain comprises within itself such a variety of physical features as is only found elsewhere distributed over much more extensive regions. It cannot be doubted, therefore, that a properly constructed map of Scotland, on a scale sufficiently distinct, if executed with fidelity, and with all the improvements of modern art, would present at once a most pleasing and highly instructive example of this species of design. That we do not already possess such a map, is not owing to any want of interest in the subject on the part of our countrymen, for Scotland has produced more works of this class than perhaps any other country of similar extent and means. But these efforts, however creditable in themselves, could not be connected so as to produce a perfect map, for want of such a basis of union, as a complete system of triangulation alone could supply. Now, this was a work which, from its vast extent and labour, required the resources of Government to accomplish, and hence the necessity for the so-called Ordnance or Government Survey, to trace the progress of which is the object of this Paper.

The first map of Scotland on record is that attributed to Ptolemy, the geographer of Alexandria, A. D. 140. In this celebrated work, it is well known the bearings are altogether wrong, as the upper part of Britain is represented bending to the east instead of stretching to the north. Nothing further of this kind worthy of notice occurs till the 14th century, when Richard of Cirencester compiled a map, in which, though he generally follows Ptolemy, he gives the true bearings of the country, and greatly adds to our knowledge of British geography.

Timothy Pont was the first projector of an atlas of Scotland. In 1608 he commenced a survey of all the counties and islands, sketching in the features on the spot. He died before his work was finished, and in 1646 his drafts and notes were put into the hands of Sir Robert Gordon of Straloch, who completed his design. All the sketches and notes thus collected were transmitted to Bleau of Amsterdam, who published his *Atlas Scotiæ* in 1654. This atlas, begun at the charge of Sir John Scott, of Scotstarvet, director of the Chancery in Scotland, was, probably, carried on and completed at the national expense. These maps, which are wonderful productions

for the time, may, however, be regarded simply as literary curiosities, interesting chiefly to the antiquary.

About the year 1688, Adair made a survey, and gave descriptions of the coasts of Scotland, which he published in a small atlas; but his sketches, as well as those of Sanson, Elphinstone, and Grierson, who succeeded him, are very inaccurate. The Rev. Alexander Bryce surveyed the northern coasts of Scotland about the year 1740; his map, published in 1744, made considerable advances in accuracy. In 1750, John Dorret, land-surveyor, published a map of Scotland, in five sheets, at the expense of the Duke of Argyll. This map had more pretension than any that preceded it, being on a much larger scale, but in construction it is still very inaccurate. Between 1751 and 1771, Mr Murdoch Mackenzie, who was employed by the Admiralty, surveyed the western coasts of Britain, from the English Channel to Cape Wrath, including the Hebrides from Lewis to Islay, and extending to the Orkney Islands. His charts were published on a scale of one inch to a mile, and were accompanied by nautical descriptions. These were considered, at the time, entitled to credit, but the recent Admiralty Surveys have proved them to be exceedingly erroneous.

In 1789, John Ainslie, an eminent land-surveyor in Edinburgh, constructed, engraved, and published a map of Scotland and its islands in nine sheets. This was the first good map of the country. The author had made an actual survey of several counties, when he was employed by the Board of Customs to survey the east coasts of North Britain; he also made many rapid surveys and sketches in remote districts. Still, though superior to any that preceded it, his map is very faulty in construction. In Ainslie's time the delineation of the physical features of a country was little understood; his mountains and hills are represented as rising insulated from their bases; no indications are given of the water-sheds dividing the river basins, and little attention is paid to the subject of light and shade. In 1792 Murdo Downie published a chart of the east coast of Scotland, in which the sea-board is very inaccurate.

The Government felt so greatly the want of a tolerable map of Scotland, during the rebellion of 1745-6, that, on its suppression, it was resolved, at the suggestion of the Duke of Cumberland, to commence an actual survey of the whole country. This undertaking

was confided to Colonel Watson, who employed in the service several young officers of engineers, among others, Mr (afterwards Major-General) Roy. The survey, which was limited to the mainland, was commenced in 1747, and completed in 1755. It was conducted with considerable skill, and was the means of illustrating many of the Roman antiquities of North Britain. The field work was carried on in summer, and the drawings were prepared in Edinburgh Castle during the winter months. Of this work, General Roy himself says that, "having been carried on with inferior instruments, and the sum allowed having been very inadequate for its proper execution, it is rather to be considered as a magnificent military sketch than a very accurate map of a country." When the drafts of this map were finished, they were deposited in the Royal Library, where they lay totally forgotten till 1804, when being required for a new map of Scotland, undertaken by Arrowsmith, at the suggestion of the Commissioners of Highland roads and bridges, they were discovered after considerable search.

Arrowsmith's map was founded on Roy's survey of the mainland, and many other materials which he deemed authentic. It was commenced in 1805 and finished in 1807, on a scale of $\frac{1}{4}$th of an inch to a mile or $\frac{1}{7}$th of the scale of the military survey. Since Arrowsmith's map appeared, many portions of the country have been surveyed and published, some of these, among which may be specially noted, Lanarkshire by Forrest, Mid-Lothian by Knox, Sutherlandshire by Burnett and Scott, and Edinburgh, Fife, and Haddington by Greenwood, have been deservedly reputed. But, as must ever be the case in private enterprises, these are confined to the wealthier and more populous districts, no recent survey having been made of any of the more remote regions. The latest effort of this kind, which is likely to prove the last, is the survey of Edinburgh and Leith within the Parliamentary boundaries, on the scale of 5 feet to a mile, by W. and A. K. Johnston, a reduction of which has recently appeared.

The principal triangulation for the Ordnance Survey of Britain commenced by General Roy, on Hounslow Heath, near London, in 1784, was extended to Scotland in 1809, but the operations were discontinued for the three following years, the persons employed having been removed to England. In 1813 the Ordnance zenith

sector was used on Kellie Law, Fife, and Cowhythe, Banffshire. In 1814-15-16 the triangulation proceeded steadily. In 1817 the zenith sector was used on Balta Island, Zetland, a new base line was measured on Belhelvie Links, near Aberdeen, and the triangulation again proceeded in 1818-19. It was suspended in 1820, but re-commenced in 1821-22, in Zetland, Orkney, and the Western Islands. In 1823 the large theodolite was removed to England and afterwards to Ireland, in consequence of which the operations in Scotland were entirely suspended during a period of sixteen years. In 1838-39-40 and 41, the triangulation for connecting the islands with each other, and with the mainland, proceeded without interruption. The principal operations are now completed, with the exception of certain observations that may be required for a few stations, with a view to its publication as a scientific work.

In 1815 the Ordnance department appointed Dr M'Culloch to make a geological examination of Scotland; his researches were continued till 1821, but for want of an accurate topographical map, his labours have unfortunately done much less service than they otherwise would have done to the cause of science.

In 1819 a military detailed survey of part of Wigtonshire and Ayrshire was commenced on a scale of 2 inches to a mile, by Capt. Hobbs and two subalterns; it was carried on, with diminishing numbers, till 1827, and extended over a space of about 937 square miles. But a survey conducted at so slow a rate, and on so small a scale, afforded no proper ground for commencing a map of Scotland, and the plans will furnish no aid whatever for the general survey.

In 1834 the Ordnance carried forward a partial secondary triangulation along the Scottish coast, from the Solway Firth to the Firth of Clyde for the use of the Admiralty surveyors.

TABLE SHOWING PROGRESS OF SURVEY.

	Survey commenced.	No. of Officers and Men employed in June 1849.	Total sum expended to 1850.	Average Annual Grant.	State of Survey in 1851.	Estimated Sum required to complete Survey.	Estimated Time required to complete survey at present rate.	Remarks.
ENGLAND. Area 37,094,400 acres.	Triangulation, 1784. Survey on 1 inch scale, 1791. Survey on 6 inch scale, 1840.	736 chiefly in the northern.	£702,000	During 60 yrs. since commencement of survey, the average grant has been nearly £12,000.	Nearly $\frac{4}{5}$ths of England and Wales are surveyed and published on the 1 inch scale. The remainder, comprising the six northern counties, is in progress, on the 6 inch scale. It is proposed afterwards to reduce the maps of these six counties in order to complete the map on the 1 inch scale. The surveys of Lancashire and Yorkshire have been completed on the 6 inch scale. It is intended, ultimately, to extend the survey on the 6 inch scale, over the whole of England, and to survey all towns, the population of which exceeds 4000.	To complete the survey of the northern counties on the 6 inch scale, £285,000. The estimated sum necessary to complete the survey of the southern portion of the country on the 6 inch scale, is £1,600,000. Expense of surveying the towns and completing the map on the 1 inch scale not yet estimated.	"With the present force at the disposal of the Ordnance the time would be endless"*	The new survey of the southern portion, on the 6 inch scale, could be done in twenty years, if unlimited funds were supplied. About 250 towns remain to be surveyed, besides those in progress in the northern counties.

SCOTLAND. Area 18,944,000 acres.	Primary Triangulation, 1809. Secondary Triangulation, 1841. Survey of South Portion, 1844.	257, only two officers, one in Edinburgh and one in the island of Lewis.	£66,000	The average grant during forty-one years has been £1609, 15s. From 1843 to 1849 the grants have varied from £9000 to £15000 but part of this has been expended in England and Ireland.	The primary and secondary triangulations are completed, with the exception of a few observations and corrections. The county of Wigton is published in 38 sheets. Kirkcudbright is surveyed, and partly in the hands of the engravers. The island of Lewis is in progress, and about $\frac{4}{5}$ths of the plans are being engraved. The county and city of Edinburgh are in progress of being surveyed. The towns of Dumfries, Wigton, and Stranraer, are surveyed, and the drawings of the plans are nearly completed.	£740,000 to complete the survey of the 6 inch scale.	50 years at least.	In order to complete the survey in ten years, the present force, and consequently the present grant, would require to be increased five times. That is to say, the force employed would require to be 1285 officers and men, and the annual grant £50,000. £25,000 would, in the same proportion, be required to complete the work in twenty years. But all the evidence produced is to the effect that the more rapidly the work is carried on, the greater will be the ultimate economy.
IRELAND. Area 20,808,271 acres.	Survey 1825.	1210. employed in contouring and revising the map.	£820,000	Average nearly £40,000 per annum. Occasionally nearly £70,000 per annum.	The survey of the country was *completed* and published in 1846, on the 6 inch scale. It is comprised in 1907 sheets (exclusive of 32 index maps), and is now sold for £400. Plans of ninety-five towns are surveyed and drawn. The plan of Dublin is engraved and published. The system of contour lines commenced in 1838 is now in progress; and the northern portion of the country is being revised and corrected.	£200,000, for the following purposes:— To complete the contouring, £120,000. To complete the revisal of northern portion now in progress, £80,000. Expense of surveying and engraving plans of towns not estimated.	30 or 40 years to complete the contours. Time for revisal not estimated.	A very large force (number not specified) would be necessary to complete the revisal and contouring within a few years. ——— A map of Ireland, on the scale of 1 inch to a mile, was originally contemplated. Its execution is postponed. The estimated cost of reducing from the 6 inch plans and engraving is £83,604.

* Parliam. Papers, 1849, vol. ix. p. 499.

In 1840 the Board of Ordnance and the Treasury directed that the survey of Scotland should be laid down on a scale of 6 inches to a mile to correspond with that of Ireland.

The secondary operations of the survey in Scotland have been carried on since 1841. In the beginning of 1844 the detailed survey of the county of Wigton was begun; it was completed in 1850 and is now engraved on the 6 inch scale, with contour lines, or lines of equal elevation, and published in 38 sheets. The survey of the county of Kirkcudbright was commenced in 1845, and it is expected that it will be finished and portions of it published during the present year.

In July 1846 the survey of the island of Lewis was commenced, out of due course, in consequence of an arrangement with the proprietor, by which he agreed to pay to the Government the sum of £1200, and to purchase 100 copies of the published maps. In January 1851 about three-fifths of this survey were completed, some of the sheets will be published during the present year, and it is expected that the whole will be finished during 1852.

In March 1850 the surveying party was removed from Wigton and Kirkcudbright shires to Mid-Lothian and the city of Edinburgh. The survey of the city is now considerably advanced, and it is expected that some of the sheets will be published in 1852. It is proposed to be engraved in outline, *i. e.*, without shading or distinction of houses from streets, on a scale of 5 feet to a mile.

The survey of the county of Edinburgh is going on, and has also made considerable progress. Plans of the towns of Wigton and Stranraer have been surveyed, on the scale of 5 feet to a mile. The town of Dumfries is surveyed, and the drawing plans are nearly finished.

This comprises all that has yet been done by the Ordnance Surveyors in North Britain.

From these statements we learn that the survey of Scotland was begun in 1809, but its progress appears to have been considered of so little importance in comparison with the surveys of other portions of the kingdom, that, whenever it was found convenient, the whole of the men and instruments employed were unceremoniously removed to England or Ireland; and that, in order to expedite the work in the latter country, the operations in Scotland were on one occasion altogether suspended during a period of sixteen years.

It will be seen from the preceding table that the total sum expended on the survey in Scotland from its commencement to the present time, has been only £66,000; while the sum expended in England is £702,000; and in Ireland, £820,000; and that, in June 1849, the number of men employed in Ireland was 1210, while in Scotland the number employed was only 257.

The average annual expenditure on the survey of Scotland during the forty-one years of its progress has been only £1609, or, omitting the sixteen years when the operations were suspended, £2640; while on that of Ireland the average expenditure has been nearly £40,000 per annum. In the Parliamentary reports on this subject, it is stated that, in 1843, the sum voted for the survey of the whole kingdom was £60,000, of which only £9000 was appropriated to Scotland; and, since 1843, the sum allotted to the survey of Scotland has averaged little more than £10,000 per annum, the same amount which is voted annually for *revising* the maps of the northern counties of Ireland already surveyed! Besides the sum of £820,000 already expended in Ireland, it is proposed to expend for the revisal of the northern counties above alluded to, £80,000; and, for completing the system of contour lines (now in progress), the further sum of £120,000, making in all £1,020,000, exclusive of the expense of engraving plans of ninety-five towns, which are surveyed and drawn.

From these reports we learn further, that the largest amount hitherto granted for the purposes of the survey in Scotland in any one year has been £15,000, and as admitted in evidence although larger sums have frequently been voted to Scotland, they have often been expended in England and Ireland. The consequence of this treatment has been, that, after a lingering progress extending over a period of forty-one years, the survey of Scotland is still little more than begun, the map of only one county, that of Wigton, forming about a sixty-fourth part of the area of the country, being published, while the survey of the whole of Ireland has been completed and published for several years, having been commenced in 1825 and finished in 1843, and that of England is now nearly finished.

A very general feeling exists in the public mind that, in this matter, Scotland has experienced most unmerited neglect, and since the expectation of immediate progress, occasioned by the fact that the Ordnance surveyors have occupied the ground, is doomed to

certain disappointment if things are allowed to continue as they are, it is to be hoped that means may at once be devised for ensuring a more satisfactory result.

The desired object might probably be best attained by such an arrangement as would ensure the entry, in the annual Ordnance estimates, of a specific sum to be devoted to this special purpose.

The amount needed depends of course on the time within which it is required to finish the work. It is shown in the table that, at the present rate of progress, *fifty years* would be necessary for its accomplishment. Now, assuming that the efficiency of the force would be in direct proportion to the numbers employed, and since the numbers are dependent on the money grants, it is clear that five times the present force or five times the amount granted would finish the survey in a fifth part of the time, or in ten years. The sum at present voted for the survey in all parts of the kingdom is £60,000, but it is shown in evidence, that if the whole force of surveyors and others capable of conducting the work are to be taken into pay, the sum of £100,000 will be required. Now, if the difference between the amount granted and that required—£40,000 a year—were voted to Scotland (in addition to the average sum of £10,000), the survey of this portion of the country would be completed in *ten years* from this date, and that without prejudice to the surveys now carried on in England and Ireland. But if it should be objected that the sum of £100,000 a year is more than could now be granted for this purpose, the question remains whether, if it cannot be otherwise attained, the speedy completion of the survey in Scotland should not be secured by suspending for a time the operations for *contouring* the map of Ireland, and for *revising* the survey of its northern portion.

Should the necessary funds be granted, it is satisfactory to know that a sufficient number of competent and well-trained surveyors and others formerly employed in Ireland, but whose services are not now required there, may at once be engaged on the survey in Scotland, and that the engraving of the maps can be carried on simultaneously with the surveying, so that no delay in the publication would be occasioned on this account.

Having recently had an opportunity of inspecting the Ordnance Survey Office at Southampton, so ably conducted under the direction of Colonel Hall and Captain Yolland, I have pleasure in bear-

ing testimony to the excellence of the methods there employed for securing accuracy and expediting the work, the latter especially, by the extensive introduction of mechanical processes of engraving, and the masterly application of the electrotype for procuring duplicates of the copperplates.

Intimately connected with the survey of the interior, and of even greater importance to the commerce of the country, is that of the sea-coasts, carried on under the Lords Commissioners of the Admiralty. It is not many years since attention was drawn by the late Mr Galbraith to the very erroneous character of all the published charts and sailing directions then available for the Firth of Clyde, in which it is shown "that the master of a vessel, trusting to the charts then in ordinary use, would almost certainly be wrecked if his reckonings were right."

It is gratifying to find that danger from this cause no longer exists in that quarter, admirable surveys being now completed of the River and Firth of Clyde, and of the lochs connected with them, many of the sheets of which are already published, and the others are in course of being engraved. The whole of the north, south, and east coasts of Scotland, with the Shetland and Orkney Islands, have been surveyed, and most of the sheets are published. The western coast of Sutherland is also surveyed, so that the portion of this great work still remaining to be accomplished comprises the coasts of Ross, Inverness, Argyll, and the Hebrides. All these surveys have been conducted by able and experienced officers under the enlightened and zealous superintendence of the Hydrographer Royal, Admiral Sir Francis Beaufort, who, in his anxiety to insure the utmost attainable accuracy, revises and corrects with his own hand every sheet of the survey before it is sent to press.

Mr Johnston then exhibited a map, shewing by colours the present state of the Ordnance and Hydrographical surveys in Scotland, and a comparative table of the proportionate scales of maps constructed from the surveys of different countries in Europe.

The following Gentleman was duly elected an Ordinary Fellow :—

Sir George Douglas, Bart., of Springwood Park.

The following Donations to the Library were announced :—

Essai Historique sur le Magnétisme et l'Universalité de son influence dans la Nature. Par M. de Haldat. 8vo.

Optique Oculaire suivie d'un essai sur l'Achromatisme de l'Oeil. Par M. de Haldat. 8vo.—*From the Author.*

On the Remains of Man, and Works of Art imbedded in Rocks and Strata, as illustrative of the connection between Archæology and Geology. By G. A. Mantell, LL.D. 8vo. — *From the Author.*

American Journal of Science and Arts. Vol. II., No. 31. 8vo. *From the Editors.*

Acta Societatis Scientiarum Fennicæ. Tom. III. Fasciculus I. 4to. —*From the Society.*

Novorum Actorum Academiæ Cæsareæ Leopold. Carol. Naturæ Curiosarum. Vol. XXII., Pars. II. 4to. — *From the Academy.*

Abhandlungen der K. Akademie der Wissenschaften zu Berlin. 1848. 4to.

Monatsbericht der K. Akademie der Wissenschaften zu Berlin. Juli 1849 ; Juni 1850. 8vo.—*From the Academy.*

French Marine Charts, with corresponding Descriptions.—*From the French Government.*

Ueber eine Kochsalz herrührende pseudomorphische Bildung im Muschelkalke der Wifergegend. Von J. F. L. Hausmann. 8vo.

Die Bleigewinnung in Südlichen Spanien in Jahre 1829. Von J. F. L. Hausmann. 8vo.

Ueber die Erscheinung des Anlaufens der Mineralkörper. Von J. F. L. Hausmann. 8vo.—*From the Author.*

Nachrichten von der Georg. Augusts. Universität. und der K. Gesellschaft der Wissenschaften zu Göttingen. Von Jahre 1849. Nr. 1–14. 12o. — *From the University.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1850–51. No. 41.

SIXTY-EIGHTH SESSION.

Monday, 3d March 1851.

Sir DAVID BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read:—

1. On Iron and its Alloys. Part I. By J. D. Morries Stirling, Esq.

2. On the Weight of Aqueous Vapour, condensed on a Cold Surface, under given conditions. By James Dalmahoy, Esq.

The paper was accompanied by two tables, containing the results of sixty-three experiments respecting the rate at which vapour condenses on a cold surface.

In planning the experiments, it was assumed that $C = m\,(f'' - f''')$, where C is the weight of moisture condensed on a surface of given area in a given time; f'' the tension of vapour at the dew-point; f''' the tension at the temperature of the condensing surface; m a co-efficient varying with the velocity of the current of air.

But, in the course of experiments, it was found that the co-efficient m was not constant, even when there was no sensible current; and that under this state of the air, it was necessary to change m into

M $(t - t''')$ in which M is constant, t the temperature of the air, and t''' the temperature of the condensing surface.

The principal object of the experiments was to determine mean values of the co-efficients m and M. The data and results necessary for this purpose were contained in the two tables before alluded to, and the following small table merely exhibits the mean values.

Mean Values.	Velocity of Current per 1″.	Number of Experiments.
M = 0·12	Insensible	15
m = 18·3	4·12 feet	11
m = 26·5	8·24	8
m = 39·7	14·8	8
m = 44·6	20·6	11

It is to be remarked, that the value of M, as given above, is only applicable when the air in contact with the cold surface is free to descend by its own weight, and that when, from any impediment to its escape, the air is not changed, there is scarcely any sensible condensation of vapour on the cold surface.

The paper concluded by examining, in connection with the preceding results, the theory proposed by Professor Phillips in explanation of the increment received by rain in the course of its descent to the earth. This theory, as is well known, ascribes the increment to to the continual condensation of vapour on the cold surfaces of the drops; and the author of this paper attempted to prove, that when the data assumed were the most favourable to the theory which the case admitted of, the observed increment of the rain was 635 times greater than would be accounted for by the rate of the experiments.

3. On the Poison of the Cobra da Capello. By Dr J. Rutherford Russell. Communicated by Dr Gregory.

The poison is of an amber colour, has a faint animal odour and an acrid taste. When treated with alcohol or ether it separates into two portions—the one soluble and the other insoluble. From some experiments Dr Russell made he concluded that both were poisonous, but is inclined to believe the soluble to be the more poisonous of the two.

He gave a detailed account of a series of experiments made upon some rabbits and a dog. The effect of the insertion of a small portion of the poison into a wound in a rabbit was in almost every case to produce death, generally preceded by stupor and sometimes by convulsions. The lungs were found gorged with blood in several

of the cases, and in some there was evidence of a severe inflammation of the pluræ having taken place. The poison took from an hour and a half to twenty-four hours to produce its fatal effect.

It produced little effect upon the dog, probably from the quantity being small.

The following Gentlemen were duly elected Ordinary Fellows:—

John Stewart, Esq., of Nateby Hall, Lancashire.
Dr John Kinnis, Deputy-Inspector of Hospitals.

The following Donations to the Library were announced:—

Medico-Chirurgical Transactions. Published by the Royal Medica and Chirurgical Society of London. General Index. Vols. I.–XXXIII. 8vo.—*From the Society.*

The Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. New Series. No. 32. 8vo. —*From the Society.*

Monday, 17th March 1851.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On a New Source of Capric Acid, with Remarks on some of its Salts. By Mr T. H. Rowney. Communicated by Dr Anderson.

The author commences his paper by mentioning the different sources from which capric acid has been obtained, and then proceeds to point out a new source for obtaining it, namely, the grain oil from the Scotch distilleries.

The grain oil, he states, consists of water, alcohol, amylic alcohol, and an oily residue, having a much higher boiling point than amylic alcohol. It is this oily residue that contains the capric acid. He obtained it by boiling the only residue with caustic potassa, which renders it soluble in water, and by adding HO, SO_3 or HCl to the alkaline solution, the capric acid is separated. He then proceeds to detail the method he followed for obtaining it pure, and its most characteristic properties, viz.,—it is solid at the ordinary temperature, and fuses at 81° F.,—it is insoluble in cold water, and slightly soluble in hot water,—very soluble in cold alcohol and ether,—and

when a large quantity of cold water is added to the alcoholic solution, the capric acid separates in crystals. The numbers obtained by analysis shewed the formula to be $C_{20}\ H_{19}\ O_3$ HO.

The author then describes the salts of capric acid that he examined, —these were the silver, baryta, magnesia, lime, copper, and soda. He also obtained capric ether and capramide. The capric ether is an oily liquid, lighter than water, its specific gravity being ·862, insoluble in cold water, but readily soluble in alcohol and ether. The capramide he obtained by acting on the ether with a strong solution of ammonia. It forms beautiful crystalline scales, insoluble in cold water, soluble in cold alcohol, and also in dilute spirit, when warmed. Its formula he found to be $C_{20}\ H_{21}\ O_2$ N.

2. On Iron and its Alloys. Part II. By J. D. Morries Stirling, Esq.

The following abstract contains a brief notice of this as well as of the former part of Mr Stirling's paper, read at last meeting:—

The author gave a short description of the various kinds of cast-iron, and a statement respecting their strengths, and of the uses to which they are more especially adapted, pointing out the discrepancies which exist between chemists as to the quantity of carbon contained in each sort. That the author's experience led him to believe that the quantities of carbon were different in the different Nos.—greater in No. 1, less in Nos. 2, 3, and 4. Slow cooling of large masses of iron renders them softer. In making the mixtures of wrought and cast iron, different proportions of wrought-iron are used; for soft iron containing much carbon (or No. 1), more malleable-iron, and for harder iron, less. Welsh, Scotch, Staffordshire iron differing much from each other—the Scotch being the softest, the Welsh the hardest. By the proper proportioning the addition of malleable-iron, the strength of cast-iron is nearly doubled, both transversely and tensilely. By melting this mixture of wrought and cast iron, and then puddling the mixture, a very superior kind of wrought-iron is obtained, and the process of refining is avoided. By the addition of *calamine* or zinc to common iron, without the admixture of wrought-iron, a very superior malleable-iron is produced, equal in appearance, when twice rolled, to iron that has been thrice

rolled, and very much stronger, or as 28 to 24½. The increased strength in the mixture of wrought and cast iron, called toughened cast-iron, renders it peculiarly adapted for wheels, pinions, &c., and for girders, columns, and other architectural uses. Several government works so constructed—the Chelsea, the Windsor, and the Yarmouth Bridges—also, at various iron-works, all rolls, pinions, and cog-wheels are made of it. The wrought-iron made either from the toughened cast, or by the admixture of calamine, is particularly useful for tension rods, chain-cables, &c. The addition of antimony and some other metals to wrought-iron in the puddling furnace gives a hard and crystalline iron, nearly allied to steel in some of its properties, and is adapted, from its hardness and crystalline character, to form the upper part of railway rails and the outer surface of wheels. When thus united to the iron containing zinc, the best sort of rail results, combining strength, stiffness, and hardness with anti-laminating properties, and being also cheaper than any other kind of hardened rail or *tire.* Compounds of copper, iron, and zinc are found to be much closer in texture, and stronger than similar compounds of copper and zinc (the proportion of iron not usually exceeding 1½ per cent.), and can be advantageously used as substitutes for gun-metal, under all circumstances, for great guns, screws, propellers, mill brasses, and railway bearings; small additions of tin and other metals alter the character of these compounds, and render them extremely manageable as regards hardness and stiffness. The advantages which these compounds possess over gun-metal are cheapness and increased strength, being about one-fourth cheaper, and one-half stronger, and wearing much longer under friction. On many railways, the alloys of zinc, iron, copper, tin, &c., have superseded gun-metal for carriage bearings. An alloy equal in tone to bell-metal, cheaper, and at the same time stronger, is made from the alloy of copper, zinc, and iron, a certain proportion of tin being added. The addition of iron seems, under most, if not all circumstances, to alter the texture of metallic alloys, rendering it closer, and the alloys, therefore, more susceptible of a high polish, and less liable to corrosion. Other alloys of iron were exhibited, some shewing the extreme closeness of texture, others possessing very great hardness, and suitable for tools, cutting instruments, &c., others possessing a high degree of sonorousness. A bell was exhibited, of fine tone; its advantages being cheapness (less than half

the price of common bell-metal) and superiority of tone. Other alloys of iron, copper, zinc, manganese, and nickel were exhibited, some bearing a near resemblance to gold, others to silver; the latter being now most extensively made in Birmingham, and gradually superseding German silver, or at least being largely used instead of that alloy, which it surpasses in lustre, closeness of texture, and freedom from tarnish. A malleable bell was also shown, the tone of which was equal, if not superior, to that of a common bell of same size: a specimen of this sort of metal was shown crushed almost flat. The author recommended its use for ship and lighthouse bells, &c.

3. On the Dynamical Theory of Heat, with Numerical Results deduced from Mr Joule's Equivalent of a Thermal Unit, and M. Regnault's Observations on Steam. By William Thomson, M.A., Fellow of St Peter's College, Cambridge, and Professor of Natural Philosophy in the University of Glasgow.

Sir Humphrey Davy, by his experiment of melting two pieces of ice by rubbing them together, established the following proposition:—

"The phenomena of repulsion are not dependent on a peculiar elastic fluid for their existence, or caloric does not exist;" and he concludes that heat consists of a motion excited among the particles of bodies. "To distinguish this motion from others, and to signify the cause of our sensation of heat," and of the expansion or expansive pressure produced in matter by heat "the name *repulsive motion* has been adopted."*

The Dynamical Theory of Heat, thus established by Sir Humphrey Davy, is extended to radiant heat by the discovery of phenomena, especially those of the polarization of radiant heat, which render it excessively probable that heat propagated through vacant space, or through diathermane substances, consists of waves of transverse vibrations in an all-pervading medium.

---

* From Davy's first work, entitled "An Essay on Heat, Light, and the Combinations of Light," published in 1799 in "Contributions to Physical and Medical Knowledge, principally from the West of England; collected by Thomas Beddoes, M.D.," and republished in Dr Davy's edition of his brother's collected works, vol. ii. London, 1836.

The recent discoveries* of the generation of heat through the friction of fluids in motion, and by the magneto-electric excitation of galvanic currents would, either of them, be sufficient to demonstrate the immateriality of heat, and would so afford, if required, a perfect confirmation of Sir Humphrey Davy's views.

Although Sir Humphrey Davy had established beyond all doubt the fact that heat may be created by mechanical work, the converse proposition, that heat is lost when mechanical work is produced from thermal agency, appears to have been first enunciated by Mayer in 1841. In 1842 the same proposition was enunciated by Joule, and a number of most admirable experiments illustrating the mutual convertibility of heat and mechanical effect, and the constancy of thermal effects through the most varied means, from given causes, are described in his paper on Magneto-electricity, and adduced in it from his former experimental researches by which the laws of the evolution of heat by the galvanic battery had been established. The same paper contains the first investigation on true principles that has ever been made of the numerical relations which connect heat and mechanical effect; and numerical determinations of "the mechanical equivalent of a thermal unit" are given as the results of two classes of experiments, in each of which mechanical work is spent, and no other final effect than the creation of heat is produced, in one class by means of magneto-electric currents, and in the other, by means of the friction of fluids in motion.

In subsequent experimental researches he has made more accurate determinations, and, from his last set of experiments on the friction of fluids, he concludes "that the quantity of heat capable of raising the temperature of a pound of water (weighed *in vacuo* and taken at between 55° and 60°) by 1° Fahr., requires for its evolution the expenditure of a mechanical force represented by the fall of 772 lb. through the space of one foot."

---

* In May 1842, Mayer announced, in the Annalen of Wöhler and Liebig, that he had raised the temperature of water from 12° to 13° cent., by agitating it. In 1843, Joule announced in the Philosophical Magazine that "heat is evolved by the passage of water through narrow tubes;" and in the month of August of that year (1843), he announced to the British Association that heat is generated when work is spent in turning a magneto-electric machine, or an electro-magnetic engine. (See his paper "on the Calorific Effects of Magneto-Electricity and on the Mechanical Value of Heat." Phil. Mag. vol. xxiii. 1843.)

The object of the present paper is threefold—

(1.) To show what modifications of the conclusions arrived at by Carnot, and by others who have followed his peculiar mode of reasoning regarding the motive power of heat, must be made when the hypothesis of the Dynamical Theory, contrary as it is to Carnot's fundamental hypothesis, is adopted.

(2.) To point out the significance in the Dynamical Theory, of the numerical results deduced from Regnault's observations on steam, and communicated about two years ago to the Society with an Account of Carnot's Theory, by the author of the present paper; and to show that, by taking these numbers (subject to correction when accurate experimental data regarding the density of saturated steam shall have been afforded), in connection with Joule's mechanical equivalent of a thermal unit, a complete theory of the motive power of heat, within the temperature limits of the experimental data, is obtained.

(3.) To point out some remarkable relations connecting the physical properties of all substances, established by reasoning analogous to that of Carnot, but founded on the contrary principle of the Dynamical Theory.

In the first part of the paper Mr Joule's principle regarding the mechanical equivalent of heat is shown to be in reality as certainly true as Carnot's would be if the hypothesis that heat is matter were not false; and it is therefore adopted by the author, not as Carnot's principle was adopted by him temporarily "as the most probable basis for an investigation of the motive power of heat" without a belief in its rigorous exactness; but, with implicit confidence, as a true law of nature.

The following axiom is also adopted:—

It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects.

From Joule's principle, and from this axiom, the two following propositions, which constitute the foundation of the theory, are deduced.

Prop. I.—When equal quantities of mechanical effect are produced by any means whatever from purely thermal sources, or lost in purely thermal effects, equal quantities of heat are put out of existence, or are generated.

Prop. II.—If an engine be such that when it is worked backwards the physical and mechanical agencies in every part of its

motions are all reversed, it produces as much mechanical effect as can be produced by any thermo-dynamic engine with the same temperatures of source and refrigerator, from a given quantity of heat.

The second of these propositions was first enunciated by Carnot, and demonstrated by him on the assumption of his principle of the permanence of heat. It was first enunciated and demonstrated, without making that assumption, upon the true principles of the dynamical theory, by Clausius, in the second part of his paper* (published in May 1850), who founds it on an axiom substantially equivalent to that quoted above. The author of the present paper gives the demonstration, which is closely analogous to Carnot's original demonstration, and the axiom on which it is founded, just as they occurred to him at a time when he was only acquainted with the first part (published in April 1850) of Clausius' paper, and was not aware that the proposition had been either enunciated or demonstrated except by Carnot.

From the establishment of the second proposition, on the principles of the dynamical theory, and an axiom that cannot probably be denied, it is shown that all the conclusions obtained by Carnot and others who have followed him and adopted his principles, which depend merely on the fundamental equation expressing "Carnot's function," in terms of certain physical properties of any substance whatever, require no modification.

But the Theory of the motive power of heat through finite ranges of temperature requires most important alterations which form the subject of the second part of the present paper. The following expressions are given for the amount of work (W) derivable from a unit of heat introduced into an engine at the temperature S, if the coldest part of the engine is at the temperature T; in terms of the portion $(1-R)$ of the unit of heat which is converted into work, and for the remainder, (R,) which is emitted as waste into the refrigerator.

$$W=J\,(1-R)\,;$$

$$R=\epsilon^{-\frac{1}{J}\int_T^S \mu\,dt}\,;$$

where J denotes the "mechanical equivalent" of a unit of heat determined by Joule.

* Poggendorff's Annalen, 1850.

Tables of the values of these quantities, for different ranges, obtained by using the values of μ shown in Table I. of the author's Account of Carnot's Theory, are given. An application to the case of the Fowey-Consols engine which, according to the data quoted in the Appendix to that paper, appears to have worked at 76 per cent. of the true duty for its range of temperature (which was assumed to be from 30° to 140° cent.), instead of only 67 per cent. of the duty according to Carnot's Theory; and to have emitted into the condenser only 82 per cent. of the heat taken in at the boiler, the remaining 18 per cent. having been converted into mechanical effect.

It is shown that the advantage originally pointed out by Carnot may be still anticipated from the use of air instead of steam, as the effective range of temperature of the air-engine can be made much greater than is practicable in the case of the steam-engine. As an example of the economy attainable by using a large range, it is shown that, with a range of from 0° to 600° cent., about three-fourths of the full equivalent is attainable by a perfect engine, while with the range from 30° to 140°, which is about the greatest that is practicable with steam-engines, even a perfect engine could not obtain more than 27, or about one-fourth of the full equivalent of the heat used.

The third part of the paper contains investigations of some formulæ with reference to the specific heats of substances of any kind, derived from the equations which express the two fundamental propositions. It contains also an application of these equations to the case of a medium consisting of two parts, of the same substance, at the same temperature, in different states. The results are applicable both to the effects of pressure on the melting points of solids, and to the conditions of saturated vapours. One of the conclusions pointed out is, the very remarkable property of saturated steam, that its "specific heat is negative," which was discovered independently by Rankine and Clausius.

The following Donations to the Library were announced :—

Philosophical Transactions of the Royal Society of London, for the year 1850. Part 2, 4to.—*From the Society.*

Observations on Days of unusual Magnetic Disturbance, made at the British Colonial Magnetic Observatories, under the depart-

ments of the Ordnance and Admiralty. Vol. I., Part 2. (1842–4), 4to.—*From the British Government.*

Annales des Mines. Tom. II. (1847); Tom. IV., Liv. 1, 5, 6, (1833); Table des Matières des 1re et 2e Séries, 1816–30; Tom. XIV., Liv. 6 (1848); Tom. XIX., Liv. 1, 2, 3, (1841); Tom. XX., Liv. 4, 5, 6 (1841); 8vo.—*From the Ecole des Mines.*

Journal of the Statistical Society of London. Vol. XIV., Part 1, 8vo.—*From the Society.*

The Geological Observer. By Sir Henry T. de la Bèche. 8vo. —*From the Author.*

Journal of the Asiatic Society of Bengal. No. 214. 8vo.—*From the Society.*

Monday, 7th April 1851.

SIR DAVID BREWSTER, K. H., Vice-President, in the Chair.

The following Communications were read:—

1. On the Geology of the Eildon Hills. By Professor J. D. Forbes.

The author first refers to a paper by Mr Milne, in the 15th Volume of the Edinburgh Transactions, on the Geology of Roxburghshire, in which the general features of this district are accurately described. The present paper contains a notice of some minuter particulars regarding the formation of the Eildon group and their boundaries obtained by detailed personal examination in 1849.

The remarkable general parallelism of the strata of greywacké which forms the basis of the geology of the neighbourhood, is first particularly insisted upon. The intrusive rocks, chiefly felspathic, which abound near Melrose, have but little, if at all, disturbed the general strike and inclination of the greywacké rocks, the former being in a direction nearly east and west, and the latter nearly vertical. The triple Eildon Hill is composed principally of brownish red felspar porphyry, sometimes resembling clink-stone, at other times containing quartz; the south-western hill shews vertical columns of the same substance. The author was able to trace the strata of greywacké to a great height on the north-western face of the two

principal Eildons; to a level in fact within two or three hundred feet of the *col* or neck which unites them; but the principal feature which he insists upon is, that the highest summit of the group appears to be composed of a mass of greywacké rock, caught up in the midst of the surrounding trap, and so metamorphosed by it as to be with difficulty recognisable; but the author considers that he has obtained a suite of specimens which leave no doubt as to the fact of the gradation.

The other important trap-rock is the trap-tufa of Melrose, of which the nature and extent were carefully examined, although the latter is still subject to doubt. The formation appears to commence close to the railway station at Melrose, and to extend in a westerly direction towards Cauldshiels Loch, its breadth being in the Rhymer's Glen still considerable, but no section which shews it could be obtained farther west. To the south of the trap-tufa behind Melrose, there occurs a remarkable patch of red sandstone, horizontally deposited, and evidently identical with that of Dryburgh, where trap-tufa also occurs. There can be little doubt but that the tufa is posterior in date to this sandstone, whilst the Eildon porphyry is older.

A collection of specimens, illustrating the paper, is deposited in the Museum of the Royal Society.

2. On certain Salts of Comenic Acid. By Mr Henry How. Communicated by Dr Anderson.

The author commenced his paper with a few observations on the comparative progress of the different departments of organic chemistry, and remarked that the subject of the polybasic acids is not so completely studied as could be wished, and that he had chosen his subject for investigation in the hope of adding some information on that point.

After giving a short history of comenic acid, he pointed out a new method for the purification of the crude acid, which consisted in the use of ammonia as a solvent, in place of potass. In this way he got a salt readily deprived of colour, and whose impure mother liquors were of use in subsequent experiments.

He then proceeded to detail the salts he had examined. The bicomenate of ammonia, just mentioned, was a salt, crystallizing in beautiful brilliant colourless prisms, whose formula is

$$NH_4\,O,\,HO,\,C_{12}\,H_2\,O_8+2\,HO.$$

They lose their water of crystallization at 212°.

The corresponding salts of potass and soda crystallize in prismatic groups; they are anhydrous, and their respective formulæ are

$$KO, HO, C_{12} H_2 O_8,$$
$$NaO, HO\ C_{12} H_2 O_8.$$

He proved the non-existence of neutral alkaline salt,—but shewed that both neutral and acid salts are formed with all the alkaline earths.

The acid lime-salt crystallizes from boiling water in transparent rhombs, whose composition is expressed by the formula

$$CaO, HO, C_{12} H_2 O_8 + 7\ aq.$$

The 7 aq. are expelled at 250° Fahr.; the neutral salt of lime is insoluble in water, and its constitution is

$$2\ CaO, C_{12} H_2 O_8, 2\ HO + 5\ aq., \text{ or}$$
$$2\ CaO, C_{12} H_2 O_8, 2\ HO + 11\ aq.,$$

according as the fluids from which it is deposited are more or less dilute; the aq. is driven off at 250° Fahr.

The bicomenate of baryta crystallizes from hot water in transparent rhombs; their composition is

$$2\ (BaO, HO, C_{12} H_2 O_8) + 13\ aq.$$

The 13 aq. are lost at 212° Fahr.; the neutral barytic salt is insoluble in water, and has the formula

$$2\ BaO, C_{12} H_2 O_8 + 2\ HO + 8\ aq.$$

The 8 aq. are expelled at 250° Fahr.

The bicomenate of magnesia crystallizes from water in crystals very like ferrocyanide of potassium; their composition is

$$MgO, HO, C_{12} H_2 O_8, 2\ HO + 6\ aq.$$

The 6 aq. being driven off at 240° Fahr., the neutral magnesia salt is insoluble in water, and has the constitution

$$2\ MgO, C_{12} H_2 O_8, 3\ HO + 8\ aq.$$

The 8 aq. are lost at 212° Fahr.

After making a few remarks on some other salts, the author pro-

ceeded to discuss the products of decomposition of comenic acid. He first shewed that it readily undergoes oxidation by nitric acid, and by solution of persulphate of iron, with the production of carbonic and oxalic acids in both cases, and elimination of hydrocyanic acid in the former.

No change is produced by the action of sulphurous acid, or of sulphuretted hydrogen.

When chlorine acts upon comenic acid or solution of bicomenate of ammonia, a new acid is produced, crystallizing in fine brilliant square prismatic needles: analysis shewed the composition to be

$$2\,HO, C_{12}\left\{\begin{matrix}H\\Cl\end{matrix}\right\}O_8 + 3\,HO.$$

The three atoms of water are expelled at 212°; in the formula of the anhydrous acid, we have that of comenic acid, in which an equivalent of hydrogen is replaced by chlorine.

This is a strong and bibasic acid, forming two series of salts: the author, after detailing the properties and products of decomposition of the acid itself, describes the appearance of some of these salts, and gives the analysis of those of silver, whose composition he shews to be

For the acid, $AgO\,HO, C_{12}\left\{\begin{matrix}H\\Cl\end{matrix}\right\}O_8$ and

For the neutral, $2\,AgO, C_{12}\left\{\begin{matrix}H\\Cl\end{matrix}\right\}O_8$.

The action of bromine is precisely similar, and furnishes an acid of the same character, appearance, and properties: its formula is

$$2\,HO, C_{12}\left\{\begin{matrix}H\\Br\end{matrix}\right\}O_8 + 3\,HO.$$

It loses its water of crystallization at 212°.

Some account is given of the salts of bromocomenic acid; and the author then goes on to examine the action of hydrochloric acid gas upon absolute alcohol holding comenic acid in suspension. He details the process by which he obtains a substance which is evidently comenovinic acid, analogous to tartrovinic, sulphovinic acid, and such bodies. It has the composition

$$HO, C_4\,H_5\,O, C_{12}\,H_2\,O_8.$$

It has an acid reaction, coagulates white of egg, &c., fuses and sub-

limes unaltered; but, though stable *per se*, is readily decomposed in presence of fixed bases: for this reason only the ammonia salt could be obtained, and that in a peculiar way; sufficient evidence was given, however, of its being a true salt of the constitution

$$NH_4\,O,\ C_4\,H_5O,\ C_{12}\,H_2\,O_8.$$

The author then gives a description of a curious change which ensues when an alkaline ammoniacal solution of comenic acid is boiled, and which results in the production of comenamic acid, which he shews to be constituted like osamic acid, it being an acid amide. It is derived from the bicomenate of ammonia by the elimination of two atoms of water; consequently, its formula, as proved by analysis, is

$$HO,\ C_{12}\,H_4\,NO_7.$$

It crystallizes with four equivalents of water in beautiful micaceous scales: its most distinctive property is the magnificent purple colour it forms with persalts of iron.

It forms crystallizable salts with a certain proportion of potass, soda, or ammonia, which have an acid reaction.

The formula of the ammonia salt is

$$NH_4\,O,\ C_{12}\,H_4\,NO_7.$$

The corresponding salt of silver is transparent and jelly-like; that of baryta crystallizes readily; its composition appears to be

$$BaO,\ C_{12}\,H_4\,NO_7 + 2\,HO.$$

A solution of the ammonia salt made alkaline gives with nitrate of silver a yellow precipitate, which speedily becomes black,—and with chlorine of barium, an insoluble white precipitate, which may be considered as having the composition expressed in the formula

$$BaO,\ C_{12}\,H_4\,NO_7 + BaO\ HO.$$

The author concludes, by saying he believes he has observed in the behaviour of comenamic acid, under certain circumstances, phenomena which will repay further investigation.

3. On the Crystallization of Bicarbonate of Ammonia in Spherical Masses. By Dr G. Wilson.

The author exhibited these spherical concretions, which had formed

in a subliming chamber, where carbonate of ammonia from gas liquor was condensed; apparently in consequence of a local whirl affecting the condensing particles. They were formed of acicular crystals, confusedly grouped, without a trace of radiation or of any regular arrangement.

4. On the Compressibility of Water. By W. J. Macquorn Rankine, Esq., C.E.

The results of the experiments of M. Grassi on the above subject (Comptes Rendus XIX.) follow sensibly this law.

The compressibility of water is inversely proportional to the density, multiplied by the temperature as measured from the absolute zero of a perfect-gas thermometer, viz. :—a point 274°·6 below the ordinary zero of the centigrade scale, and 462°·28 below that of Fahrenheit's scale.

Hence the compressibility of water follows sensibly the same law with that of a gas.

Let $\mathfrak{d}$ be the compressibility of water per atmosphere; D its density, the maximum density being unity; τ the absolute temperature, then

$$\mathfrak{d} = \frac{1}{K \tau D}$$

where

K = 72 atmospheres per centigrade degree, or
40 atmospheres per degree of Fahrenheit.

D may be computed by the author's formula for the expansion of liquids.—(*Edinburgh New Philosophical Journal, October* 1849.)

Dr Gregory read a letter from his Grace the Duke of Argyll, describing the locality of a white muddy deposit sent with the letter, and exhibited in a dry state to the Society. The deposit occurs in what appears to be an old channel between Loch Baa, at the foot of Ben More in Mull, and the sea, passing through a dead flat. The lake discharges itself now by another channel. Dr Gregory found the deposit to be silicious, with a trace of organic matter, and to consist entirely of the silicious cuirasses of infusoria, like the bergmehl of Sweden. Navicula viridis, and some bacillaria had been observed in it by Dr Gregory, and Dr Douglas Maclagan, who undertook a microscopical examination, found, besides Navicula viridis,

several species of Eunotia, and the beautiful rings of Gallionella varians. The deposit occurs in the old channel to a very considerable depth, a long stick having failed to reach the bottom of the white mud.

The following Gentleman was duly elected an Ordinary Fellow :—

ELMSLIE WILLIAM DALLAS, Esq.

The following Donations to the Library were announced :—

Primo Decennio di Osservazioni Meteorologiche fatto nella Specula di Bologna, ridotte esposte ed applicate da Alessandro Palagi, M.D. 4to.—*From the Author.*

Neue Denkschriften der Allgemeine Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Bd. 11. 4to.

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nos. 144–192. 8vo.—*From the Society.*

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft bei ihrer 35 Versammlung in Aarau. 1850–1. 8vo.

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft bei ihrer 34 Versammlung in Frauenfeld. 1849. 8vo.—*From the Society.*

Naturwissenschaftliche Abhandlungen gesammelt und durch subscription herausgegeben von W. Haidinger. Bde. 2 and 3. 4to.

Berichte über die Mittheilungen von Freunden der Wissenschaften in Wien. herausg. von W. Haidinger. Bde. 3, 4, 5, 6. 8vo.—*From the Editor.*

Contribution to the Vital Statistics of Scotland. By James Stark, M.D. 8vo.—*From the Author.*

Journal of the Asiatic Society of Bengal. Nos. 215 and 216. 8vo. —*From the Society.*

Mémoires de l'Institut de France. Académie des Sciences. Tom. 20, 21, 22. 4to.

Mémoires présentés par divers Savants à l'Académie des Sciences de l'Institut National de France. Tom. 11, 12. 4to.—*From the Academy.*

Collection of Specimens illustrating the Geology of the Eildon Hills. —*By Professor Forbes.*

Monday, 21st April 1851.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Economy of Single-acting Expansive Steam Engines, and Expansive Machines generally; being Supplements to a Paper on the Mechanical Action of Heat. By W. J. M. Rankine, Esq., C.E.

The author, in the first place, states the equations, which, when used in conjunction with the Tables in the Appendix to the original paper referred to, serve to compute the action of Cornish pumping engines. They are similar in form to those of M. de Pambour, but differ in the expressions for the pressure and volume of steam, and for its expansive action, which the author in the original paper deduced from theory.

Let A denote the area of the piston.

l, the length of the stroke.

n, the number of double strokes in unity of time.

c, the fraction of the whole bulk of steam above the piston at the end of a down stroke, which is employed in filling the valve-boxes and the clearance of the cylinder.

l', the length of stroke performed, when the steam is cut off.

s, the ratio of expansion of the steam, so that

$$\frac{1}{s} = (1-c)\frac{l'}{l} + c\,; \quad \frac{l'}{l} = \frac{\frac{1}{s} - c}{1-c}.$$

Let W be the weight of steam expended in unity of time.

P_1, the pressure at which it enters the cylinder.

V_1, the corresponding volume of unity of weight of steam, which may be found by means of Table I., already referred to.

F, the resistance per unit of area of piston not depending on the useful load.

R, the resistance per unit of area of piston arising from the useful load.

Z, the ratio of the total action of the steam at the expansion s, to its action at full pressure; which may be found from Table II.

E, the useful effect in unity of time.

The moment of closing the equilibrium-valve is supposed to be so adjusted, whether by trial or by calculation, as to prevent any sensible loss of power from clearance and steam passages. Let l'' be the portion of up-stroke, remaining to be performed at the proper moment for closing this valve, then

$$\frac{l''}{l} = \frac{c\,(s-1)}{1-c}$$

This adjustment being made, the two following are the fundamental equations of motion of the engine :—

$$E = R\,A\,l\,n = W\,V_1\,(P_1\,Z - F) = \text{useful effect in unity of time.}$$

$$W = \frac{A\,l\,n}{V_1\,s} = \text{steam expended in unity of time.}$$

The following are deduced from them. Ratio of mean load to maximum pressure :—

$$\frac{R+F}{P_1} = \frac{Z}{s};$$

Duty of unity of weight of steam—

$$\frac{E}{W} = V_1\,(P_1\,Z - F);$$

Weight of steam expended per stroke—

$$\frac{W}{n} = \frac{A\,l}{V_1\,s}.$$

The results of the last two formulæ are compared with the experiments made by Mr Wicksteed on a large Cornish pumping-engine at Old Ford at five different ratios of expansion; and the agreement is found to be so close as to prove that the results of the theory are practically correct.

The results of experiment generally shew a somewhat less expenditure of steam for a given duty than theory indicates. This is conceived to arise from the cylinder being heated by a jacket communicating with the boiler, in which the temperature is much higher than the highest temperature in the cylinder.

The theory is next applied to the solution of the problem of the economy of Cornish engines. The merit of first proposing this problem is believed to belong to the Artizan Club, who have offered premiums for its solution, "with a view," as they state, "to enable

" those who, from their position, cannot take part in the discus-
" sions of the various scientific societies to give the profession the
" benefit of their studies and experience." As the author's paper will not be published until some time after the date fixed by the Artizan Club for receiving Essays, he expresses a confident belief that it will not be considered as interfering with their design.

The problem in question is this; given the following—

P_1, the initial pressure in the cylinder.

F, the resistance independent of the useful load.

$l\,n$, the amount of the length of the effective strokes in unity of time.

h, the annual cost of producing unity of weight of steam per unit of time, which consists of two parts, cost of fuel and interest of cost of boilers.

k, the annual interest of the cost of the engine, per unit of area of piston.

It is required to determine the ratio of expansion s (and thence the dimensions of the engine), such that the annual expense due to interest and fuel

$$h\,W + k\,A$$

shall be a minimum as compared with the useful effect E.

This condition is fulfilled by making the ratio

$$\frac{Z - \frac{F}{P_1} S}{\frac{h\,l\,n}{k\,V_1} + S}$$

a maximum.

This problem is solved graphically, by drawing two straight lines on a diagram, a copy of which is annexed to the paper on a scale large enough for practical purposes.

The following formulæ serve to compute the dimensions of the engine.

Mean resistance of the useful load per square foot of piston:—

$$R = \frac{Z}{s} P_1 - F$$

$$\text{Area of piston} = A = \frac{E}{R\,l\,n}$$

Expenditure of steam per unit of time,—

$$W = \frac{E}{R\,V_1\,s}.$$

A numerical example is added of the solution of this problem of economy.

The next portion of this paper relates to the proportion of heat converted into expansive power by machines.

A machine working by expansive power consists essentially of a portion of some substance which alternately expands and contracts under the influence of heat; receiving heat and expanding at a higher temperature; emitting heat and contracting at a lower.

The quantity of heat emitted is less than the quantity received, the difference being transformed into expansive power. To make the proportion of heat thus transformed a maximum, the temperatures of reception and emission should each be a constant quantity, so that none of the heat received or emitted may be employed in producing changes of temperature. The temperature must be raised and lowered by compression and expansion only.

Carnot was the first to assert the law, that when a machine works under these conditions, the ratio of the power evolved to the heat originally received, is a function of the temperatures of reception and emission only, and independent of the nature of the working substance. But his investigation not being founded on the principle of the mutual conversion of heat and power, involves the fallacy that power can be produced out of nothing.

The merit of combining Carnot's law with that of the convertibility of heat and power, belongs to M. Clausius and Professor William Thomson.

The author, having applied to this question the principles laid down in the introduction and first section of his paper on the Mechanical Action of Heat, has arrived at the following conclusions :—

First.—Carnot's law is not an independent principle in the theory of heat, but is deducible as a consequence from the equations of the mutual conversion of heat and expansive power given in the first section.

Secondly.—The maximum value of the ratio of the quantity of

heat converted into expansive power to the total quantity received by the body, is equal to that of the difference between the temperatures of reception and emission, to the absolute temperature of reception diminished by a certain constant denoted by $\varkappa = C n \mu b$ in the paper; which constant must be the same for all substances in nature, in order that molecular equilibrium may be possible. That is to say, let τ_1 be the absolute temperature at which heat is received, and τ that at which it is emitted; then

$$\frac{\text{maximum of heat transformed into power}}{\text{total heat received}} = \frac{\tau_1 - \tau_0}{\tau_1 - \varkappa}$$

The value of $\varkappa$ is as yet unknown, but as an approximation it may be treated as small enough to be neglected in comparison with τ_1.

Although this formula is very different from Professor Thomson's in appearance, the numerical results are nearly the same.

The conditions of working to which Carnot's law is strictly applicable are not attainable in the steam-engine, and are different from those on which the author's formulæ and tables in the fourth section are based. The proportion of heat converted into power in the steam-engine is therefore found, both by experiment and by calculation, to be less than that indicated by Carnot's law. The author illustrates this fact by examples, theoretical and experimental.

2. On the Products of the Destructive Distillation of Animal Substances. Part II. By Dr Anderson.

The author commenced by referring to the first part of his paper, in which he had determined the existence, among the products of destructive distillation of animal substances, of picoline, which he had before obtained from coal-tar, and of a new base to which he had given the name of Petinine; and had also indicated the existence of certain other bases. On proceeding to the further investigation of these substances, he had been much impeded by deficiency in materials, and had, at length, been compelled to operate on no less than 250 gallons, or about a ton of bone oil.

By separating the bases in a manner similar to that employed in his first experiments, but with some modifications detailed in the

paper, the author had succeeded in obtaining a great variety of products which had escaped his notice when operating on a smaller scale. Among the most volatile products, and accompanying ammonia, he had detected the presence of a base of the formula C_2 H_5 N, and which had all the properties of methylamine. He had also determined the presence of propylamine C_6 H_9 N, and rendered probable the existence of ethylamine C_4 H_7 N.

In the examination of the bases boiling at higher points great difficulties had been experienced, and even after many rectifications the indications of fixed boiling points were extremely indistinct, but, by the examination of the platinum salts, the author ascertained the existence of a base boiling at about 250°, having the formula C_{10} H_5 N, for which he proposed the name of Pyridine, and of another boiling about 310°, which has the formula C_{14} H_9 N, and has the constitution of toluidine, but differs entirely from it in properties. To this base the author gives the name of Lutidine.

At the close of the paper the author also refers shortly to the existence of an entirely different series of bases, to which he gives the provisional name of *Pyrrol Bases*, which are distinguished by the property of splitting up, under the action of strong acids, into a red resinous matter, and one or other of the bases of the picoline series.

3. On Carmufellic Acid. By Dr Sheridan Muspratt and Mr Danson.

In this paper the authors, after mentioning the various researches hitherto made on cloves and the substances therein discovered, describe the preparation of the new acid.

20 lb. of cloves are extracted by boiling water, and the decoctions, after being concentrated to six gallons, were acted on by nitric acid, first in the cold, afterwards with the aid of heat. The action is brisk, and irritating vapours are given off, which affect the eyes strongly. Oxalic and carbonic acids are also formed. A white deposit is separated by filtration, and the filtered liquid, on evaporation, yields yellow micaceous scales of the acid, which are obtained colourless by combining it with lead and separating it by sulphuretted hydrogen.

The acid is insoluble in alcohol, ether, and cold water, but soluble

in hot ammonia, potash, and large quantities of boiling water. It forms gelatinous salts with the solutions of salts of baryta, strontia, or lime, and also with those of lead; green flakes with salts of copper; yellow flakes with sesquisalts of iron; white flakes with salts of protoxide of iron and silver. These precipitates shrink much in drying, feel like mica, and dissolve in nitric and hydrochloric acids.

The analyses of the acid yielded results indicating the formula $C_{24} H_{20} O_{32}$. The baryta and lead salts appear to contain the acid entire, which is unusual, their formula being $MO, C_{24} H_{20} O_{32}$, instead of the base replacing an equivalent of water.

The authors are occupied with eugenic acid and the neutral oil of cloves.

4. Farther Remarks on the Intermitting Brine Springs of Kissingen. By Professor Forbes.

On the 7th of January 1839, I communicated to the Royal Society of Edinburgh a pretty detailed account of the singular mineral and gas springs of Kissingen, in Bavaria, then much less known than at present to English travellers. I refer to this paper, printed in the Edinburgh New Philosophical Journal, April 1839, for the details of the most curious of these, a saline spring called Kunde-Brunnen, which was at that time regularly periodic; a copious and turbulent discharge of brine, mixed with torrents of carbonic acid gas, recurring six or eight times in the twenty-four hours. This phenomenon, exactly as described in my paper, appears to have continued with slight variation ever since, that is, for a period of twelve years, subject, however, to the variation formerly mentioned, that when the brine is actively withdrawn by pumps, for the manufacture of salt, the periods lengthen. I have no additional observations of importance to offer on this spring, beyond the remarkable fact of the continuity of these variations, surely the more remarkable when we recollect that the spring is entirely artificial, rising through an Artesian bore 312 Bavarian feet deep.

Much greater changes have taken place in the Schönborn Quelle, briefly referred to in my former paper as having a depth of 550 Bavarian feet, as overflowing once in seven or eight minutes, and yielding a feeble supply of weak brine, containing only one and a

half per cent. of salt. The boring process has been carried on, though slowly, nearly ever since, and it is at present one of the deepest Artesian bores ever made, being, at the time of my visits, 1878 feet. The bore passes first through *Bunter Sandstein* (which forms the bed of the valley, the surrounding heights being capped by muschel kalk and keuper), to a depth of 1240 feet; the only spring met with in that space being the small salt spring which existed in 1838, which occurred at a depth of 222 feet, with a temperature of 8° Reaumur; it yielded only 6 cubic feet per minute, with 1½ per cent. of salt. On piercing the sandstone from between it and the gres vosgien rose a powerful spring, containing 2½ per cent. of salt, of a temperature of 15° Reaumur, or 66° Fahr., and yielding from 93 to 100 cubic feet of water per minute, and probably quite as much carbonic acid gas. These fluids were driven up the shaft with enormous force by subterranean pressure.

Not satisfied with this considerable success, the intelligent inspector, Mr Knorr, continued the laborious and expensive work of boring, in the confident hope of reaching, if not the bed of salt, at least the spring of stronger brine. At 1590 feet the upper limit of the zechstein or magnesian limestone was reached, and at 1680 feet a source of carbonic acid gas appeared, which increased the height to which the water could be driven up. At last, at 1740 feet, the limits of the rock salt formation was attained, the boring irons bringing up saliferous clay, mixed with gypsum and anhydrite, which continued down to the depth of 1878 feet, and which is capable of impregnating the salt water to saturation, coming up charged with between 27 and 28 per cent. of salt. It is to be observed, however, that it is only that portion of the spring rising at 1240 feet which can descend to the bottom and then rise up in this state of saturation. The greater part retains its old per-centage of 2½. It is therefore of urgent consequence to continue the bore until a spring has been reached at a lower level than the salt, and of sufficient power to rise through it to the surface, and in that way alone can this mineral treasure be made available for use; and as the thickness of the rock salt formation is supposed to be 700 or 800 feet, it may be long yet before this object is obtained. At present, if I understand right, the spring is not, properly speaking, intermittent, but it may easily be rendered so by a singular artifice which I saw put in practice. When the workmen wish to stop the flow of water, in

order to proceed with the boring, they surround the rods with a plug of clay bandaged with cloth, so that by lowering it into the bore-hole, which contracts at a certain depth, they stop it as when one corks a phial. In an instant all is still, the turmoil of water foaming with gas is at an end; and this tranquillity lasts for many days, and when the spring again rises, it may be stopped out in a similar way. Inspector Knorr thinks that he has established a kind of law in these remissions to this effect, that the number of days which elapse before the spontaneous return of the spring is *thrice* the number during which it had before flowed. Thus, if the spring has been allowed to rise uninterruptedly for five days, and is then stopped, it will remain fifteen days out.

Under ordinary circumstances, the gas and water exhaust their projectile force in a cauldron or shaft of considerable depth and width, in which the Artesian bore terminates; but Mr Knorr gave us an opportunity of witnessing its ascensional power, by fitting a tube into the entrance of the bore, thus leading it up to the surface of the ground; it then spouted from that level to a height of at least 50 feet in the free air, having at its emission a diameter equal to that of a man's thigh. When we consider that it has first to rise 1240 feet through the earth, and that it is impelled by a mysterious and unseen, but apparently exhaustless, power beneath, and with this astonishing force, the phenomenon is certainly very surprising.

I shall only add the temperatures of some remarkable springs, taken in 1850 with great care, and which are the very same with those observed by me twelve years previous, the results of which may be found in my former paper.

Schönborn Quelle (Saline) 93 cubic feet per minute.

		Therm.		Corrected.
1850.	June 25, 5 P.M.	67°·2′	A 3.	
	„ 26, 4 P.M.	66·8	Troughton.	66·3
Ragozzi (Medicinal.)				
	June 26, noon	52·05	Troughton.	51·55
	July 2, 5 P.M.	52·25	do.	51·75
Pandur (Medicinal.)				
	June 26, noon.	51·8	do.	51·3
	July 2, 5 P.M.	52·0	do.	51·5

		Therm.		Corrected.
Max-Brunnen (Medicinal.)				
1850. July 2,	Noon.	49·4	Troughton.	48·9
Bocklet (Four miles from Kissingen, Chalybeate.)				
July 1,	4 P.M.	50·7	Troughton.	50·2
Kapelle (Chapel at Kissingen, fine fresh-water spring in front of, accompanied by much gas.)				
June 28,	6 P.M.	51·5	A 3.	

The above agree usually within a few tenths of a degree with the observations made fully a month later in 1838.

5. On a Method of Discovering Experimentally the Relation between the Mechanical Work spent and the Heat produced by the Compression of a Gaseous Fluid. By Professor William Thomson.

The important researches of Joule on the thermal circumstances connected with the expansion and compression of air, and the admirable reasoning upon them expressed in his paper,* "On the Changes of Temperature produced by the Rarefaction and Condensation of Air;" especially the way in which he takes into account any mechanical effect that may be externally produced, or internally lost in fluid friction, have introduced an entirely new method of treating questions regarding the physical properties of fluids. The object of the present paper is to show how, by the use of this new method, in connection with the principles explained in the author's preceding paper on the Dynamical Theory of Heat, a complete theoretical view may be obtained of the phenomena experimented on by Joule, and to point out some of the objects to be attained by a continuation and extension of his experimental researches.

The formulæ investigated in this paper are divided into three classes:—

1. Those which are certainly true for all substances, or for all fluids.

2. Those which are necessarily true for any fluid subject to Boyle's and Dalton's laws of density.

* Phil. Magazine, 1845. Vol. xxvi., p. 369.

3. Those which would be true for every fluid subject to those laws of density, if "Mayer's hypothesis," that the heat evolved by compression, when the temperature is kept constant, is the exact equivalent of the work spent in the compression, were true for any one such fluid.

The principal formulæ of the first class are two which express respectively the quantity of heat evolved by the compression, by uniform pressure in all directions, of any substance whatever, kept at a constant temperature; and the total quantity of heat evolved by a given quantity of fluid forced through a small orifice, before it attains to precisely its primitive temperature.

The former of these formulæ reduces itself to

$$H = \frac{E}{\mu (1 + E t)} W$$

where W is the mechanical work spent in the compression, and H the quantity of heat emitted, for any fluid subject to Boyle's and Dalton's laws. This formula was first given in the Appendix to the author's Account of Carnot's Theory,—where it was shown to follow from Regnault's observations on the pressure and latent heat of saturated steam, that $\frac{\mu (1 + E t)}{E}$ cannot be nearly constant for all temperatures, if the density of saturated steam fulfils Boyle's and Dalton's laws; but that the value of this expression is very nearly J, the mechanical equivalent of a thermal unit, for ordinary atmospheric temperatures. Hence this theory, and the assumed density of saturated steam, are in full agreement with Joule's experiments which establish as approximately true for atmospheric temperatures the hypothesis which was assumed irrespectively of experimental verification, by Mayer.

The other formula mentioned above becomes, for a fluid subject to the "gaseous" laws,—

$$H = \left\{ \frac{1}{J} - \frac{E}{\mu (1 + E t)} \right\} p' u' \log \frac{p}{p'}$$

where p is the uniform pressure in one portion of a long tube; p' the uniform pressure in another portion, separated from the former by a piece of tube containing a partition with a very small orifice; t the temperature of the entering fluid up to the locality

where the rushing commences, and the pressure begins to vary, which is also the temperature to which the fluid is reduced in the other part of the tube before it reaches the end; and H the quantity of heat which must be taken away to fulfil this condition, during the passage of a quantity of fluid of volume u', under a pressure equal to p', at the temperature t, through the apparatus.

From this it follows, that the test of Mayer's hypothesis for any particular temperature is to try whether, when the air enters at that temperature, it leaves the *rapids* at precisely the same temperature. Calorimetrical methods of experimenting upon this apparatus, like those of Joule, but susceptible of being continuously used for any period of time, are suggested for determining, possibly with very great accuracy, the value of

$$\frac{1}{J} - \frac{E}{\mu(1+Et)}$$

for any temperature, should it not be exactly zero for all temperatures, as it would be if Mayer's hypothesis were true. The value of J having been determined by Joule with very remarkable accuracy, it follows that such experimental researches, besides affording the solution of the problem which forms the subject of this paper, would determine the values of Carnot's function, by an entirely new method, for the temperatures of the experiments.

Dr Gregory exhibited a specimen of a beautiful fibrous silky white salt, taken about thirteen years ago, by Donald Campbell, Esq., from the joinings of the slabs of limestone forming the roof of the highest of the chambers of construction, discovered by Colonel Vyse above the King's Chamber in the great pyramid of Ghizeh. No other part is lined with limestone, and there only this salt appeared. Dr Gregory found it to be absolutely pure chloride of sodium, so pure, indeed, that it had not undergone the slightest change in thirteen years, although only wrapped in paper. Had lime or magnesia been present, it would have deliquesced. Under the microscope, the fibres exhibited oblique angles and fractures, and they may possibly be regular six-sided prisms, derived from the cube. Dissolved in water, the salt crystallized by evaporation in the usual form. When heated, it gave off a trace of water, but re-

tained its form and aspect. The origin of this salt is obscure; but it is probably derived from the limestone, which is known to be nummulite, and believed to be marine limestone.

The following Gentleman was duly elected an Ordinary Fellow:—

The Rev. Dr James Grant, Edinburgh.

The following Donations to the Library were announced:—

Journal of the Royal Geographical Society of London. Vol. XX., Part 2. 1851. 8vo.—*From the Society.*

Supplement to the Catalogue of the Athenæum Library. 8vo.—*From the Athenæum.*

Abhandlungen der Philosophisch-Philologischen Classe der K. Bayerischen Akademie der Wissenschaften. Bd. VI., Abtheil 1. 4to.

Abhandlungen der Historischen Classe der K. Bayerischen Akademie der Wissenschaften Bde. I.–VI., Abtheil 1. 4to.

Gelehrte Anzeigen herausgegeben von Mitgliedern der K. Bayerischen Akademie der Wissenschaften. Bde. XXX., XXXI. 4to.

Almanach der K. Bayerischen Akademie der Wissenschaften, für 1849. 12mo.—*From the Academy.*

Annalen der Königlichen Sternwarte bei München. Bd. IV. 8vo. —*From the Observatory.*

Abhandlung über das Schul. und Lehrwesen der Muhamedaner im Mittelalter. Von Dr D. Haneberg. 4to.—*From the Author.*

Ueber die Praktische Seite Wissenschaftlicher Thätigkeit. Von Fr. v. Thiersch. 4to.—*From the Author.*

Einige Worte über Wallensteins Schuld. Von Dr Rudhart. 4to.—*From the Author.*

Ueber die Politische Reformbewegung in Deutschland im XV. Jahrhunderte und den Antheil Bayerns an derselben. Von Dr Const. Höfler. 4to.—*From the Author.*

Bulletin de la Société de Géographie. 3me Série. Tom. XIV. 8vo.—*From the Society.*

The American Journal of Science and Arts. Vol. II., No. 32. 8vo.—*From the Editors.*

Experimental Researches on Electricity. By Michael Faraday, LL.D.—*From the Author.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1851–52. No. 42.

Sixty-Ninth Session.

Monday, 1st December 1851.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On the Total Eclipse of the Sun on 28th July 1851, observed at Göteborg; with a description of a new Position Micrometer. By William Swan, Esq.

I observed the eclipse from a hill about a mile to the north of Göteborg, situated in latitude 57° 43′ 5″, longitude $0^h\ 47^m\ 49^s$, in company with Mr Edward Lane, Advocate, who kindly rendered me his valuable assistance in making the observations for time. The telescope I used was furnished by Mr Adie of Edinburgh. It has a good object-glass, with an aperture of 2·1 inches, and about 31·5 inches focal length; and the eye-piece employed in observing the eclipse magnified about 28 times. A dark glass, lent me by Professor Chevallier, consisting of a coloured prism achromatized by a prism of colourless glass, slid in a groove before the eye-piece, so as to admit of being instantly removed. This glass made the sun's image appear yellow, slightly tinged with green.

As considerable discrepancies occur in the positions assigned by different observers to the prominences seen at the eclipse of 1842,

I made use of a position micrometer, devised for the purpose of rapidly determining their places on the sun's limb. A circular plate of metal, 8 inches in diameter, was attached, by a collar passing through its centre, to the sliding tube of the telescope, to which it was firmly clamped, so as not to turn round. This plate was covered with a disc of card on the side next the eye-end of the telescope. Inside the tube carrying the plate, another tube carrying the eye-piece, slid smoothly, so as to admit of being freely turned round. The latter tube was furnished with two springy arms, pointing in opposite directions, in front of the plate, like the hands of a clock, and having steel points, by which holes could be pricked in the card disc. A small level was attached at right angles to one of these arms, and parallel to the card disc. In the eye-piece were fixed three equidistant parallel spider lines, the outer two being placed at an interval equal to the moon's apparent diameter calculated for the time of the total phase of the eclipse; so that when the outer wires were made to embrace the moon's disc, the middle wire would pass through its centre. The instrument was adjusted for observation, by causing the middle wire to coincide with a plumb-line, seen at a distance through the telescope; while, at the same time, the bubble of the level was brought to the middle of its tube by turning the arms, which were then securely clamped to the tube carrying the eye-piece. It is evident that if, after this adjustment, the bubble were again brought to the middle of the tube, while the outer wires were made to embrace the sun's disc, the middle wire would pass through its vertex; and two holes being pricked in the card, the line joining them would represent the sun's vertical diameter at the time of observation. If next, while the sun was kept between the outer wires, the middle wire was made to bisect any object at its limb, and holes were again pricked in the card, the angles between the lines joining the respective pairs of holes would measure the angular distance of the object from the sun's vertex. In this manner the positions of the red prominences, seen during the total phase of the eclipse, could be rapidly registered on the card, without ever removing the eye from the telescope.

The observations of time were made by means of a box chronometer by Adams of London, obligingly furnished by Lieutenant C. A. Pettersson, of the Navigation School of Göteborg. It was compared with his standard chronometer about 3^h 15^m before the com-

mencement of the eclipse, and again, the following day, after an interval of 24 hours.

The weather, which previously had a very unfavourable aspect, improved rapidly before the commencement of the eclipse. An extremely thin cirrous cloud, however, continued to overspread the sky; but this did not sensibly impair the definition of the sun, which was remarkably good until some time after the total phase, when the sky became more thickly clouded. During the progress of the eclipse the cusps continued quite sharp, until the sun was reduced to an extremely narrow crescent of about 90° or less, when they were sensibly rounded. This appearance became more and more decided, until at length the moon's limb was quickly joined to that of the sun by numerous thick lines, which occupied nearly all the remaining crescent of the sun. The spaces between the lines were at first rudely rectangular, but gradually became rounded so as to resemble a string of bright beads, after which they finally disappeared. The same phenomena were seen in a reverse order after the total phase, but the beads were not so numerous as before.

The moment Baily's beads were gone, I looked at the sun with the naked eye, and saw the corona fully formed. The darkness at first seemed great, owing to the contrast of the recent sunshine; and Mr Lane found it necessary to use a candle in reading the chronometer. The horizon, chiefly towards the north, was filled with light of a magnificent orange-yellow, or amber-colour, by which I had no difficulty in writing down the time of the commencement of the totality. It was a ghastly spectacle to behold—a black sun surrounded by a pallid halo of light, and suspended in a sky of sombre leaden hue; and there was so much to observe in the effects of the eclipse on the appearance of the landscape, that probably about 15^s elapsed before I looked again through the telescope, having previously removed the dark glass. The first object that attracted my attention was a remarkable hook-shaped red prominence, situated 110° 30′ to the west of the sun's vertex; and immediately afterwards I saw another prominence with a serrated top, resembling a chain of peaked mountains, which was situated a little below the first, 132° 40′ to the west of the sun's vertex. At the risk of offering what may be deemed a whimsical comparision, I can best describe the form of the hook-shaped prominence by saying it resembled the Eddystone or Bell Rock lighthouse, transferred to the sun, with its top beginning

to fuse and bend over, like a half-melted rod of glass. The prominences increased very sensibly in height during the progress of the total phase, until at length the hook-shaped one had attained an altitude which I estimated at rather more than 2′. Both had remarkably definite outlines, and their forms were permanent so long as they remained visible; the only change being, that they increased in height, and became wider at the base, evidently owing to the moon's motion gradually disclosing those parts of them which were nearest to the sun's limb. They were of a full rose-tint, and were distinctly visible to the naked eye by the strong red tinge they imparted to the corona in their neighbourhood.

The corona cast no sensible shadow. To the naked eye, it appeared slightly tinged with pale purple or lavender colour, which, perhaps, was owing to the contrast of the strong yellow light in the horizon; for, when viewed through the telescope, it was silvery white. It was distinctly radiated, and shewed no trace of annular structure. The most striking feature it presented was the appearance of brilliant beams of light, which shone out in various directions. They were sharply defined, and brighter than the rest of the corona; and they were visible to some distance beyond its general outline. The most remarkable of these objects was a mass of light of a tolerably regular conoidal form, with its base towards the sun, and the curvature of its sides somewhat concave outwards, situated 28° 30′ to the east of the sun's vertex.

The first of the following Tables contains the observations, by means of the position micrometer, of the red prominences, and of the only spots visible near the sun's limb on the day of the eclipse, with the times of observation; the second, the times of the different phases of the eclipse as observed by me, and also Lieutenant Pettersson's observations of time, which he has kindly placed at my disposal; and the third, a series of thermometric observations. The latter were made by means of two small thermometers by Adie of Edinburgh, which were suspended in the shade. Their scales, by a recent comparison with his standard thermometer, were found correct to the tenth of a degree.

TABLE I.

Object Observed.	Time of Observation. Göteborg Mean Time.	Angle from Sun's Vertex.
Group of spots 1′·5 from sun's limb,	$1^h\ 37^m$	96° 30′ West.
Single spot 1′ from sun's limb, .	1 40	62 0 East.
Hook-shaped red prominence,	about 3 58	110 30 West.
Serrated prominence,	about 3 58	132 40 West.
Bright rays in corona,	about 3 58	28 30 East.

TABLE II.

	Observed by Messrs Swan and Lane in Lat. 57° 42′ 57″·3, Long. $0^h\ 47^m\ 45^s·2$.	Observed by Lieutenant C. A. Pettersson, in Lat. 57° 42′ 6″ 2, Long. $0^h\ 47^m\ 51^s·0$.
Commencement of eclipse, . . .	$2^h\ 53^m\ 4^s·4$ (About 2^s too late.)	$2^h\ 53^m\ 3^s·86$
Beginning of totality,	3 55 52·6	3 55 58·22 (Too late.)
End of totality, .	3 59 8·1	3 59 8·22
End of eclipse, . .	4 57 57·8 (Possibly too late.)	4 58 2·59 (Difficult to observe.)

TABLE III.

Göt. Mean Time.	Dry Thermometer.	Wet Thermometer.
2^h 45^m	66°	60°
3 0	64	59
3 15	62	57·5
3 30	61	56·6
3 45	60	57
3 50	57·8	55·5
4 10	57	55
4 30	58·5	56
4 45	60	57
4 55	62·3	59·5
5 5	62	58·5
5 30	61	57·5

2. On the Total Solar Eclipse of July 28, 1851, as seen on the west coast of Norway. By Professor C. Piazzi Smyth.

The author, who was in the party of Dr Robinson, Mr Alan Stevenson, and others, mentioned the very kind manner in which the Hydrographical Department had not only lent its instruments, but even caused them to be altered and adapted for the occasion, and also spoke of the liberal conduct of the Board of Northern Lights in conveying the observers to the station selected. This was on the Bue island, on the western coast of Norway, in lat. 61° 9′ 42″, and long. E. 27^m 0^s.

The arrangements were, however, defeated in a great measure by the cloudy state of the sky, which prevented any thing being seen of the sun or moon during or after the totality.

The instant of the commencement of the phenomenon was, however, observed, as well as an interesting case of an apparent repetition of it; and a good idea was obtained of the amount of personal and instrumental equation affecting the optical part only of the observations, and reaching, in this instance, the large quantity of 1^m and 50^s.

The darkness which came on at the same moment, was much more intense than would otherwise have been the case had the sky been clear. The heavens appeared all cloudy and black, except a small strip on the north horizon, which became of a lurid-red

colour. Except in that quarter, where some very distant mountain tops were visible out of the range of the moon's shadow, the land and sea were of a dark olive-green hue; and the awful aspect of the whole was felt to be quite capable of producing those effects on ignorant men which history records; while the Norse peasants about confirmed such a conclusion by their sudden and terrified flight.

3. On the Nature of the Red Prominences observed during a Total Solar Eclipse. By Professor C. Piazzi Smyth.

The author remarked, that the various observers who had seen the eclipse of 1842, gave such generally similar testimony of the place and the size of the red prominences as satisfactorily established them to be some celestial phenomenon. Then as to the question, whether they belong to the sun or the moon, the observers themselves were unanimous in the former view, and the red points then became flaming masses of fire some 40,000 miles in height.

The author, however, was by no means satisfied with the exactness of the proofs alleged; he had tried experiments, suggested by Mr Nasmyth, for making the red points appear, if real, but without success; and he further alluded to the different shapes given by the various observers to the same prominence, as rather militating against the idea of its being a large body at the distance of the sun.

On the other hand, if the red points be merely the light of the sun diffracted somehow at the moon's edge, the difference amongst observers at small distances on the earth's surface would be much more easily explained; and he found that by introducing a small ball into the telescope when directed to the sun, and making it act similarly to the moon during the total eclipse, that very similar-looking points and tongues of pink flame could be produced.

He had not, however, yet been able to make the eclipsing-ball *occult* the artificial pink prominences, and, therefore, would only attempt to establish that the solar existence of the points is only probable; and that those who hold it to be proved, should contrive some means by which they may shew the said things in real being, without getting some moon, natural as in the eclipse, or artificial, as in the experiment, to stand in front of the sun, and act on its light by diffraction or otherwise.

4. **Dr Traill then gave the following Notice of some of the recent Astronomical Discoveries of Mr Lassell, and exhibited an accurate lithograph by him of Saturn, with the recently-detected Dark Ring, &c. &c.**

Mr William Lassell, of Starfield, near Liverpool, who has gained a high reputation by his admirable method of constructing large reflecting telescopes, has largely added to his scientific character within the present year (1851), by the discovery of an eighth satellite to Saturn, and determining its period of revolution; and also, by the detection of two new satellites of Uranus. This last discovery is thus annouuced by him in a letter in my possession:—

"I have discovered two new satellites of Uranus. They are interior to the innermost of the two bright satellites discovered by Sir William Herschel, and generally known as the second and fourth. It would appear, that they are also *interior* to Sir William Herschel's first satellite, to which he assigns a period of revolution of about five days and twenty-one hours—(but which satellite I have as yet been unable to recognise.)

"I first saw these two, of which I now communicate the discovery, on the 24th of October, and had then little doubt that they would prove satellites. I obtained further observations of them on the 28th and 30th of October, and also last night; and find, that for so short an interval, the observations are well satisfied by a period of revolution of almost exactly four days for the outermost, and two and a half days for the closest. They are very faint objects—certainly have not the brightness of the two conspicuous ones, but all four were, last night, steadily visible, in the quieter moments of the air, with a magnifying power of 778 on my 20 feet reflector."—November 3, 1851.

It is well known, that the noble instrument here alluded to is the work of the hands of this eminent astronomer. Its focal distance is 20 feet. The great mirror is 2 feet in diameter, $2\frac{8}{10}$ inches in thickness, and weighs 420 lb. Mr Lassell's method of obviating the flexure of the mirror by its own weight, when resting on its edge, is exceedingly ingenious. A series of twenty-seven screws, arranged in triplets in three-armed iron plates, thus ∴, press against the back of the mirror, so as to keep its true figure unchanged by position. Nothing can exceed the perfection of the metallic composition, and

the beauty of the polish. I may add, that for attaining a true parabolic figure in the grinding, Mr Lassell employs a beautiful mechanism of his own invention, which is put in motion by a small one-horse-power steam-engine. The *powers* which he uses with this fine instrument, are,—

For planets, from 300 to 800.
For fixed stars, from 600 to 1200.
For double and triple stars, from 1200 to 1800.

The following Donations to the Library were announced :—

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschapen te Haarlem. Tweede Versameling, 7 Deel, 4to.—*From the Society.*

An Essay Explanatory of the Tempest Prognosticator, in the building of the Great Exhibition for the Works of Industry of all Nations. By George Merryweather, M.D. 8vo.—*From the Author.*

Letters to a Candid Inquirer on Animal Magnetism. By W. Gregory, M.D. 12mo.—*From the Author.*

Flora Batava. 165 Aflevering. 4to.—*From the King of Holland.*

Astronomical Observations made at the Radcliffe Observatory, Oxford, in the year 1848. By M. J. Johnson. Vol. IX. 8vo.—*From the Radcliffe Trustees.*

Astronomical Observations made at the Radcliffe Observatory, Oxford, in the year 1849. By M. J. Johnson. Vol. X. 8vo. —*From the Radcliffe Trustees.*

Proceedings of the Zoological Society of London, 1835, 1836, 1837, 1838, 1840, 1841, 1844, 1845, 1846. 8vo.—*From the Society.*

Reduction of the Observations of Planets, made at the Royal Observatory, Greenwich, from 1750 to 1830, under the Superintendence of G. B. Airy, Esq. 4to.

Reduction of the Observations of the Moon, made at the Royal Observatory, Greenwich, from 1750 to 1830, under the Superintendence of G. B. Airy, Esq. 2 vols. 4to.

Catalogue of 2156 Stars, formed from the Observations made during the twelve years from 1836 to 1847, at the Royal Observatory, Greenwich. 4to.

Results of the Observations made at the Royal Observatory, Greenwich, 1847, 1848, 1849. 4to.—*From the Observatory.*

Results of the Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, 1848 and 1849. 4to.

Description of the Instruments and Process used in the Photographic Self-Registration of the Magnetical and Meteorological Instruments, at the Royal Observatory, Greenwich. 4to.

Account of Improvements in Chronometers, made by Mr John J. Giffe. 4to.—*From the Royal Observatory.*

Papers and Proceedings of the Royal Society of Van Diemen's Land. Vol. I., Parts 1 and 2. 8vo.—*From the Society.*

Astronomische Beobachtungen auf der Königliche Universitäts Sternwarte in Königsberg:—herausgegeben von H. L. Busch. Abtheil. 23. Fol.—*From the Observatory.*

Abhandlungen der Königliche Gesellschaft der Wissenschaften zu Göttingen. Band. 4. 4to.—*From the Society.*

Nachrichten von der Georg-Augusts Universität und der Königliche Gesenschaft der Wissenschaften zu Göttingen, 1850, Nos. 1–17. 12mo.—*From the Society.*

Beiträge zur Metallurgischen Krystallkunde. Von J. F. L. Hausmann. 4to.—*From the Author.*

Handbuch der Mineralogie. Von J. F. L. Hausmann. 1er. Theil. 8vo.—*From the Author.*

Plan and Description of the Original Electro-Magnetic Telegraph. By W. Alexander, Esq. 8vo.—*From the Author.*

Minutes of Proceedings of the Institution of Civil Engineers, containing Abstracts of the Papers and of the Conversations. Vol. I.–VIII. (1837–50.) 8vo.

Catalogue of the Library of the Institution of Civil Engineers. 8vo. —*From the Institution.*

Journal of the Statistical Society of London. Vol. XIV., Part 2. 8vo.—*From the Society.*

Journal of the Horticultural Society of London. Vols. I., II., III., IV., V., and VI. Parts 2 and 3. 8vo.—*From the Society.*

Notice sur les Altitudes du Mont Blanc et du Mont Rose, determinées par des Mesures Barométriques et Géodésiques. Par M. le Commandant Deleros. 8vo.—*From the Author.*

The American Journal of Science and Arts. 2d Series. Vol. II. No. 33. 8vo.—*From the Editors.*

Journal of the Asiatic Society of Bengal. Nos. 217 and 218. 8vo. —*From the Society.*

Archives du Muséum d'Histoire Naturelle, publiées par les Professeurs-Administrateurs de cet Etablissement. Tom. V., Liv. 1 & 2 (Paris.) 4to.—*From the Museum.*

Quarterly Journal of the Chemical Society, No. 14. 8vo.—*From the Society.*

Verzangenheit und Zunkunft der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. Von Dr C. G. Nees v. Esenbeck. 4to.—*From the Author.*

Compendium der Popularen Mechanik und Maschinenlehre. Von Adam Ritter von Burg. 8vo.

Compendium der Höheren Mathematik. Von Adam Ritter von Burg. 8vo.

Ueber die von dem Civil. Ingénieur Herrn Kohn, angestellten Versuche um den Einfluss oft wiedénholter Torsionen auf den Molekularzustand des Schmiedeisens auszumitteln. Von A. von Burg. 8vo.

Programm für die Ordentlichen und Ausserordtlichen Vorlesungen welche am K. K. Polytechnischen Institute zu Wien im Studienjahre. 1850–51. Staat finden werden. Von A. von Burg. 4to.

Kuppfertafeln zum Compendium des Populären Mechanik und Maschinenlehre. Von A. von Burg. 4to. — *From the Author.*

Eighteenth Annual Report of the Royal Cornwall Polytechnic Society. 1850. 8vo.—*From the Society.*

Théorie Mathématique des Oscillations des Baromètre, et recherches de la loi de la variation moyenne de la Température avec la Latitude. Par M. E. Liais. 8vo.—*From the Author.*

Astronomical Observations, made during the year 1846, at the National Observatory, Washington. Vol. II. 4to.—*From the Observatory.*

Annales de l'Observatoire Physique Central de Russie, publiées par A. T. Kupffer. 1847. Nos. 1 and 2. 4to. *From the Observatory.*

Memorias de la Real Academia de Ciencias de Madrid. Tomo 1°, 1ª Partie. 4to.—*From the Academy.*

Resumen de las Actas de la Academia Real de Ciencias de Madrid, en al año Academico de 1849 & 1850. 8vo.—*From the Academy.*

Contributions to Astronomy and Geodesy. By Thomas Maclear, Esq., F.R.A.S. 4to.—*From the Author.*

Verhandelingen der Eerste Klasse van het Koninklijk-Nederlandsche Instituut van Wetenschappen, Letterkunde, en Schoone Kunsten te Amsterdam. 3th Reeks, 4th Deel. 4to.

Tijdschrift voor de Wis-En Natuurkundige Wetenschappen, uitgegeven door de Eerste Klasse van het Koninklijk-Nederlandsche Instituut van Wetenschappen, Letterkunde, en Schoone Kunsten te Amsterdam. 4th Deel. 8vo.—*From the Institute.*

Memoirs of the Royal Astronomical Society. Vol. XIX. 4to.—*From the Society.*

Transactions of the Microscopical Society of London. Vol. III., Parts 1 and 2. 8vo.—*From the Society.*

Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. N.S. No. 34. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XIV., Part 2. 8vo. *From the Society.*

Quarterly Journal of the Chemical Society. No. 15. 8vo.—*From the Society.*

Papers and Proceedings of the Royal Society of Van Diemen's Land. Vol. I., Part 3. 8vo.—*From the Society.*

American Journal of Science and Arts. Vol. XII., Nos. 34 and 35. 8vo.—*From the Editors.*

Journal of the Asiatic Society of Bengal. N.S. No. 45. 8vo.—*From the Society.*

Proceedings of the Liverpool Literary and Philosophical Society. Sessions 38 and 39. No. 6. 8vo.—*From the Society.*

Archives du Muséum d'Histoire Naturelle, publiées par les Professeurs-Administrateurs de cet Etablissement. Tom. V., 3me Liv. 4to.

Muséum d'Histoire Naturelle de Paris. Catalogue Méthodique de la Collection des Reptiles. 1re Liv. 8vo.

——— Catalogue de la Collection Entomologique. Classe des In-

sectes ordre Coléoptères. 1re et 2me Liv. 8vo. *From the Museum.*

Transactions of the Linnæan Society. Vol. XX., Parts 2 and 3. 4to.

Proceedings of Do. Do. Nos. 41, 42, 43, 44. 8vo.

List of Fellows of Do. Do. 1850. 4to.—*From the Society.*

Bericht über die in Jahren 1848 und 1849 auf den Stationen des Meteorologischen Instituts in Preussischen Staate angestellten Beobachtungen. Von H. W. Dove. Fol.—*From the Author.*

Observations made at the Magnetical and Meteorological Observatory at the Cape of Good Hope. Vol. I., Magnetical Observations, 1841 to 1846. 4to.—*From the British Government.*

Journal of the Horticultural Society of London. Vol. VI., Part 4. 8vo, and a List of Members.—*From the Society.*

Journal of the Asiatic Society of Bengal, 1851. No. 4. 8vo.—*From the Society.*

Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. VIme Serie. Sciences Mathématiques, Physiques et Naturelles. Tom. 6me, 1re Partie. Sciences Mathématiques et Physiques. Tom. IVme Liv. 3 and 4. 4to.

Mémoires présentés à l'Académie Impériale des Sciences de St Pétersbourg, par divers Savants et les dans ses Assemblées. Tom. VIme, Liv. 5 & 6. 4to.—*From the Academy.*

Observations faites à Nigré-Taguilsk (Monts Oural), Gouvernement de Perm. Années 1848 et 1849. (1850.) 8vo.—*From the Observatory.*

Proceedings of the American Philosophical Society. Vol. V., Nos. 45 and 46. 8vo.—*From the Society.*

Mémoires sur le Digitaline, par MM. Homolle et Quevenne. 8vo. (2 copies).—*From the Authors.*

On the Silurian Rocks of the South of Scotland. By Sir Roderick I. Murchison. 8vo.—*From the Author.*

Three Letters to the Inhabitants of Ceylon, on the Advantages of Vaccination. By John Kinnis, M.D. 8vo.

Contributions to the Military Medical Statistics of China. By John Kinnis, M.D.—On the Military Stations, Barracks, and Hospital of Hong Kong (written in 1846). On the Health of

H. M. and Hon. E. I. Company's Troops serving in China, from 1st April 1845 to 31st March 1846. 8vo.

Contributions to the Military Medical Statistics of the Bombay Presidency, 1851. By John Kinnis, M.D. 8vo.—*From the Author.*

Proceedings of the Geological Society of London. Vol. IV., Nos. 99, 101, 102, 103. 8vo.

Quarterly Journal of the Geological Society of London. Nos. 21, 22, 23, 24, 25, 26, 27, 28. 8vo.—*From the Society.*

Papers relating to the University of Sydney, and to the University College, Sydney, New South Wales. Printed at the desire of Sir J. F. W. Herschel, Bart., G. B. Airy, Esq., Professor Malden, and Henry Denison, Esq. 1851. 8vo.—*From the Editors.*

Journal of the Asiatic Society of Bengal. Nos. 208 to 210. Oct. to Dec. 1849. 8vo.—*From the Society.*

Proceedings of the Royal Astronomical Society. Vol. XI., No. 9. 8vo.—*From the Society.*

Monday, 15*th December*.

SIR DAVID BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read :—

1. On the Centrifugal Theory of Elasticity, and its connection with the Theory of Heat. By W. J. M. Rankine, Esq., C.E.

This paper contains investigations founded on the supposition, that that part of the elasticity of bodies which depends upon heat, arises from the centrifugal force of the revolutions of the particles of elastic atmospheres surrounding nuclei or atomic centres. The author has laid before this Society and the British Association several papers founded on this supposition, which he has elsewhere termed the hypothesis of molecular vortices.

The author's previous investigations were confined to atoms in which the particles of the elastic atmospheres might, without sensible error, be treated in calculation as being distributed in concentric spherical layers round their nuclei or centres, each layer being of equal density throughout, and having its particles throughout in a similar

state of motion. It might be doubted, therefore, whether the conclusions arrived at were applicable to any substances except gases, or very limpid liquids, in which the mutual actions of the atoms are similar in all directions.

To remedy this defect the present paper has been prepared, in which no definite supposition is made respecting the arrangement of the atomic centres, the distribution of their atmospheres, or the form of the orbits which the particles of those atmospheres describe. If the hypothesis, therefore, is a sound one, the conclusions are applicable to all substances. It will be seen that they are all consistent, and for the most part identical with those deduced from the more limited supposition. The most important are the following:—

Let Q denote the mechanical value of the quantity of heat, that is to say, the mechanical power corresponding to the vis-viva of the molecular revolutions, in unity of weight of a substance. Let h be the specific elasticity of the atomic atmosphere of the substance; k, a specific constant depending on the nature of the substance; τ, its absolute temperature as measured by a perfect-gas thermometer, and reckoned from a point 274°·6 centigrade = 494°·28 Fahrenheit, below the temperature of melting ice; and $\varkappa$, a constant depending on the thermometric scale, and the same for all substances in nature. Then

$$\tau = \varkappa \left(\frac{2\,Q}{h\,k} + 1 \right)$$

$\dfrac{h\,k}{2\,\varkappa}$ is the *real specific heat* of the substance.

The *expansive pressure* of any body is composed of two parts; one depending jointly on density and heat, the other a function of density alone. Let P be the total expansive pressure, p the part depending jointly on density and heat, and V the volume of unity of weight of the substances, so that $\dfrac{1}{V}$ is its mean density. Then

$$P = p + f\,(V)$$

Let μ be the weight of the atmospheric part of an atom; M, the total weight; G_1, a certain function of the density; and G'_1, G''_1, &c., the successive differential co-efficients of that function with respect to the hyperbolic logarithm of V. Also let

$$H_1 = \frac{\varkappa\, G_1}{\tau} - \frac{\varkappa^2\, G'_1}{\tau^2} + \frac{\varkappa^3\, G''_1}{\tau^3} - \&c., \; ad.\, inf.$$

Then

$$p = \frac{h \mu G_1}{M V H_1}$$

This formula was successfully applied in a previous paper, to the representation of M. Regnault's experiments on the expansion of gases, the co-efficients being determined empirically.

If the substance is in the state of perfect gas,

$$P = p = \frac{h \mu \tau}{\varkappa M V}$$

Let V_0 be the volume of unity of weight of any substance in the state of perfect gas, under unity of pressure, at some fixed absolute temperature τ_0. Then

$$\frac{h \mu}{\varkappa M} = \frac{V_0}{\tau_0}$$

The foregoing are the principal conclusions arrived at in the first section of the paper, which treats of the relations between heat and expansive *pressure*.

The second section treats of the relations between heat and expansive *power*.

Let the indefinitely small quantity of heat which must be communicated to unity of weight of a substance, to produce the variation of temperature $\delta \tau$, simultaneously with the variation of volume δV, be denoted by

$$\delta . Q = \delta Q + \delta Q'$$

δQ being the portion which remains in the body as *sensible heat*, being directly employed in increasing the velocity of the molecular revolutions, and $\delta Q'$, the variation of *latent heat*, being that which is transformed into expansive power and molecular action, in altering the form and sizes of the orbits of the revolving particles. Then

$$\delta Q = \frac{h k}{2 \varkappa} . \delta \tau$$

$$\delta Q' = \delta \tau . (\tau - \varkappa) \left(\frac{h \mu}{M \tau^2} + \int \frac{d^2 p}{d \tau^2} d V \right)$$

$$+ \delta V . (\tau - \varkappa) \frac{d p}{d \tau}$$

The integral being so taken as to be $= 0$ for the state of perfect gas.

Those two equations comprehend the whole theory of the mechanical action of heat, and agree with those given in the author's previous paper on that subject. In that paper the assistance of *Joule's Law* was used in investigating the second equation; in the present paper it is deduced directly from the hypothesis. The following are some of its consequences.

Let $P \delta V$ be the expansive power given out by the body while the variations $\delta \tau$ and δV take place. Then

$$\delta Q + \delta Q^1 - P \delta V = \delta \Psi (V, \tau)$$

is the exact variation of a function of τ and V. This is the mathematical expression of *Joule's Law.*

Let unity of weight of a substance be brought from the volume V_0, and absolute temperature τ_0, by the process (a), to the volume V_1 and absolute temperature τ_1, and restored to the original volume and temperature by the *reverse* of the process (b). Let τ_a and τ_b be a pair of temperatures in the two processes, corresponding to the same value of $\int \frac{d p}{d \tau} d V$. The result of the pair of processes will be the transformation of a certain quantity of heat into expansive power, whose value is as follows:—

$$\int_{V_0}^{V_1} P \, d V (a) - \int_{V_0}^{V_1} P d V (b) = \int_{V_0}^{V_1} (\tau_a - \tau_b) \frac{d p}{d \tau} d V.$$

This equation comprehends as a particular case, *Carnot's Law* of the effect of machines working by expansion.

The following equation, hitherto known for perfect gases only, is shewn to be true for all fluids. Let a denote the velocity of sound in a fluid; K_V and K_P the specific heats at constant volume and constant pressure; then,

$$a = \sqrt{\left(g \cdot \frac{d P}{d \cdot \frac{1}{V}} \cdot \frac{K_P}{K_V}\right)}$$

2. On the Computation of the Specific Heat of Liquid Water at various Temperatures, from the Experiments of M. Regnault. By W. J. Macquorn Rankine.

The experiments of M. Regnault having been made by introducing water at a high temperature from a boiler into a calorimeter, containing water at a low temperature, and power exercised by the steam in the boiler in expelling the water was converted into heat by fluid friction, thus producing a rise of temperature in the calorimeter, for which allowance ought to be made in calculating the specific heat of liquid water from each experiment. Mr Joule's determination of the dynamical value of the specific heat of liquid water at low temperatures affords the means of calculating the correction required in each case.

The author of this paper having thus corrected several of the results computed by M. Regnault, shews that they agree nearly with this empirical formula :—

$$\frac{K}{K_0} = 1 + a\left(T - T_0\right)^2$$

Where K is the specific heat of liquid water at the temperature T of an air thermometer, K_0 its specific heat at T_0, the temperature of its maximum density (which is 4·1° centigrade, or 39·4° Fahr.) and a, a constant coefficient, whose values are—

For the centigrade scale, . .	0·000001
For Fahrenheit's scale, . .	0·000000309

The paper is illustrated by three tables: the first shewing the correction of M. Regnault's results; the second exhibiting a comparison between the experiments and the formula, and the third giving the results of the formula for every tenth degree of the centigrade scale, from 0° to 260°.

3. On the Quantities of Mechanical Energy contained in a Fluid Mass, in different states, as to Temperature and Density. By Professor William Thomson.

Let p be the pressure of a fluid mass when its volume and temperature are v and t respectively, and let $M\,dv + N\,dt$ be the

quantity of heat that must be supplied to it to augment its volume by $d\,v$ and its temperature by $d\,t$. The mechanical value of the work done upon it to produce this change is the excess of the mechanical value of the quantity of heat that has to be added above that of the work done by the fluid in expanding, and is therefore

$$J\,(M\,d\,v+N\,d\,t)-p\,d\,v.$$

It was shewn in the author's paper on the Dynamical Theory of Heat, that this expression is the differential of a function of v and t, so that, if this function be denoted by φ, we have,—

$$\varphi\,(v,\,t)=\int\{(JM-p)\,d\,v+N\,d\,t\}$$

This function would, if the constant of integration were properly assigned, express the *absolute quantity of mechanical energy contained in the fluid mass.* Failing an *absolute* determination of the constant, we may regard the function φ as expressing the mechanical value of the whole agency required to bring the fluid mass from a specified *zero* state to the state of occupying the volume v and being at the temperature t. In the present paper some formulæ are given, by means of which it is shewn that nearly all the physical properties of a fluid may be deduced from a table of the values of φ for all values of v and t; and experimental methods connected with the experimental researches proposed in the author's last paper, are suggested for determining values of φ for a gaseous fluid mass.

4. On a Mechanical Theory of Thermo-Electric Currents. By Professor William Thomson.

It was discovered by Peltier that heat is absorbed at a surface of contact of bismuth and antimony in a compound metallic conductor, when electricity traverses it from the bismuth to the antimony, and that heat is generated when electricity traverses it in the contrary direction. This fact, taken in connection with Joule's law of the electrical generation of heat in a homogeneous metallic conductor, suggests the following assumption, which is the foundation of the theory at present laid before the Royal Society.

When electricity passes in a current of uniform strength γ through a heterogeneous linear conductor, no part of which is permitted to

vary in temperature, the heat generated in a given time is expressible by the formula

$$A\,\gamma + B\,\gamma^2$$

where A, *which may be either positive or negative, and* B, *which is essentially positive, denote quantities independent of* γ.

The fundamental equations of the theory are the following :—

$$F\,\gamma = J\left(\gamma\,\Sigma\,\alpha_t + B\,\gamma^2\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (a)$$

$$\Sigma\,\alpha_t = \Sigma\,\alpha_t\left(1 - \epsilon^{-\frac{1}{J}\int_T^t \mu\,d\,t}\right) \quad . \quad . \quad . \quad . \qquad (b)$$

where F denotes the electromotive force (considered as of the same sign with γ, when it acts in the direction of the current) which must act to produce or to permit the current γ to circulate uniformly through the conductor ; J the mechanical equivalent of the thermal unit ; $\alpha_t\,\gamma$ the quantity of heat evolved in the unit of time in all parts of the conductor which are at the temperature t when γ is infinitely small ; μ "Carnot's function"* of the temperature t ; T the temperature of the coldest part of the circuit ; and Σ a summation including all parts of the circuit.

The first of these equations is a mere expression of the equivalence, according to the principles established by Joule, of the work, $F\,\gamma$,† done in a unit of time by the electromotive force, to the heat developed, which, in the circumstances, is the sole effect produced. The second is a consequence of the first and of the following equation :—

$$\varphi.\,\gamma = \mu\,\Sigma\,\alpha_t\,\gamma.\,(t - T) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (c)$$

where φ denotes the electromotive force when γ is infinitely small, and when the temperatures in all parts of the circuit are infinitely nearly equal. This latter equation is an expression, for the present circumstances, of the proposition‡ (first enunciated by Carnot, and first established in the dynamical theory by Clausius) that

* The values of this function, calculated from Regnault's observations, and the hypothesis that the density of saturated steam follows the "gaseous laws," for every degree of temperature from 0° to 230° cent., are shewn in Table I. of the author's "Account of Carnot's Theory," *Transactions*, vol. xvi., p. 541.

† See Philosophical Magazine, Dec. 1851, "On Applications of the Principle of Mechanical Effect," &c.

‡ "Dynamical Theory of Heat" (*Transactions*, vol. xx., part II.) Prop. II., &c.

the obtaining of mechanical effect from heat, by means of a perfectly reversible arrangement, depends in a definite manner on the transmission of a certain quantity of heat from one body to another at a lower temperature. There is a degree of uncertainty in the present application of this principle, on account of the conduction of heat that must necessarily go on from the hotter to the colder parts of the circuit; an agency which is not reversed when the direction of the current is changed. As it cannot be shewn that the thermal effect of this agency is infinitely small, compared with that of the electric current, unless γ be so large that the term B γ^2, expressing the thermal effect of another irreversible agency, cannot be neglected, the conditions required for the application of Carnot and Clausius's principle, according to the demonstrations of it which have been already given, are not completely fulfilled: the author therefore considers that at present this part of the theory requires experimental verification.

1. A first application of the theory is to the case of antimony and bismuth; and it is shewn that the fact discovered by Seebeck is, according to equation (c), a consequence of the more recent discovery of Peltier referred to above,—a partial verification of the only doubtful part of the theory being thus afforded.

2. If $\Theta\,\gamma$ denote the quantity of heat evolved, [or $-\Theta\,\gamma$ the quantity absorbed] at the surface of separation of two metals in a compound circuit, by the passage of a current of electricity of strength γ across it, when the temperature t is kept constant; and if φ denote the electromotive force produced in the same circuit by keeping the two junctions at temperatures t and t', which differ from one another by an infinitely small amount, the magnitude of this force is given by the equation

$$\varphi = \Theta\,\mu\,(t' - t) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (d)$$

and its direction is such, that a current produced by it would cause the absorption of heat at the hotter junction, and the evolution of heat at the colder. A complete experimental verification of this conclusion would fully establish the theory.

3. If a current of electricity, passing from hot to cold, or from cold to hot, in the same metal produced the same thermal effects; that is, if no term of $\Sigma\,\alpha_t$ depended upon variation of temperature from point to point of the same metal; we should have, by equation (a)

$$\varphi = \mathrm{J}\,\frac{d\,\Theta}{d\,t}(t'-t)\,;\ \text{and therefore, by } (d),\ \frac{d\Theta}{d\,t} = \frac{1}{\mathrm{J}}\,\Theta\,\mu.$$

From this we deduce

$$\Theta = \Theta_0\ \epsilon^{\frac{1}{\mathrm{J}}\int_o^t \mu\,d\,t}\,;\ \text{and}\ \varphi = (t'-t)\,\mu\,\Theta_0\ \epsilon^{\frac{1}{\mathrm{J}}\int_o^t \mu\,d\,t}$$

A table of the values of $\frac{\varphi}{\Theta_0\ (t'-t)}$ for every tenth degree from 0 to 230 is given, according to the values of μ,* used in the author's previous papers; shewing, that if the hypothesis just mentioned were true, the thermal electromotive force corresponding to a given very small difference of temperatures, would, for the same two metals, increase very slowly, as the mean absolute temperature is raised. Or, if Mayer's hypothesis, which leads to the expression $\frac{\mathrm{JE}}{1+\mathrm{E}\,t}$ for μ, were true, the electromotive force of the same pair of metals would be the same, for the same difference of temperatures, whatever be the absolute temperatures. Whether the values of μ previously found were correct or not, it would follow, from the preceding expression for φ, that the electro-motive force of a thermo-electric pair is subject to the same law of variation, with the temperatures of the two junctions, whatever be the metals of which it is composed. This result being at variance with known facts, the hypothesis on which it is founded must be false; and the author arrives at the remarkable conclusion, that *an electric current produces different thermal effects, according as it passes from hot to cold, or from cold to hot, in the same metal.*

4. If $\vartheta\,(t'-t)$ be taken to denote the value of the part of $\Sigma\,\alpha_t$ which depends on this circumstance, and which corresponds to all parts of the circuit of which the temperatures lie within an infinitely small range t to t'; the equations to be substituted for the preceding are,

$$\varphi = \mathrm{J}\,\frac{d\,\Theta}{d\,t}\,(t'-t) + \mathrm{J}\,\vartheta\,(t'-t) \quad . \quad . \quad . \quad . \quad (e)$$

and therefore, by (d)

$$\frac{d\,\Theta}{d\,t} + \vartheta = \frac{1}{\mathrm{J}}\,\Theta\,\mu \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (f)$$

5. The following expressions for F, the electromotive force in a

* The unit of force adopted in magnetic and electro-magnetic researches, being that force which, acting on a unit of matter, generates a unit of velocity in the unit of time, the values of μ and J used in this paper are obtained by multiplying the values used in the author's former papers, by 32·2.

thermo-electric pair, with the two junctions at temperatures S and T differing by any finite amount, are then established in terms of the preceding notations, with the addition of suffixes to denote the particular values of Θ for the temperatures of the junctions.

$$\left.\begin{aligned} F &= \int_T^S \mu\,\Theta\,dt = J\left\{\Theta_S - \Theta_T + \int_T^S \vartheta\,dt\right\} \\ &= J\left\{\Theta_S\left(1-\epsilon^{-\frac{1}{J}\int_T^S \mu\,dt}\right) + \int_T^S \vartheta\left(1-\epsilon^{-\frac{1}{J}\int_T^t \mu\,dt}\right)dt\right\} \end{aligned}\right\} \quad (g)$$

6. It has been shewn by Magnus, that no sensible electromotive force is produced by keeping the different parts of a circuit of one homogeneous metal at different temperatures, however different their sections may be. It is concluded that for this case $\vartheta = 0$; and therefore that, for a thermo-electric element of two metals, we must have,—

$$\vartheta = \Psi_1(t) - \Psi_2(t)$$

where Ψ_1 and Ψ_2 denote functions depending solely on the qualities of the two metals, and expressing the thermal effects of a current passing through a conductor of either metal, kept at different uniform temperatures in different parts. Thus, with reference to the metal to which Ψ_1 corresponds, if a current of strength γ pass through a conductor consisting of it, the quantity of heat *absorbed* in any infinitely small part PP′ is $\Psi_1(t)(t'-t)\gamma$, if t and t' be the temperatures at P and P′ respectively, and if the current be in the direction from P to P′. An application to the case of copper and iron is made, in which it is shewn that, if Ψ_1, and Ψ_2 refer to these metals respectively, if S be a certain temperature defined below (which, according to Regnault's observations, cannot differ much from 240° cent.), and if T be any lower temperature; we have

$$\int_T^S \{\Psi_1(t) - \Psi_2(t)\}\,dt = \Theta_T + \frac{1}{J}F,$$

since the experiments made by Becquerel lead to the conclusion, that at a certain high temperature iron and copper change their places in the thermo-electric series (a conclusion which the author has experimentally verified), and if this temperature be denoted by S, we must consequently have $\Theta^S = 0$.

The quantities denoted by Θ_T and F in the preceding equation being both positive, it is concluded that, *when a thermo-electric current passes through a piece of iron from one end kept at about 240° cent., to the other end kept cold, in a circuit of which the remainder is copper, including a long resistance wire of uniform temperature throughout or an electro-magnetic engine raising weights, there is heat evolved at the cold junction of the copper and iron, and (no heat being either absorbed or evolved at the hot junction) there must be a quantity of heat absorbed on the whole in the rest of the circuit. When there is no engine raising weights, in the circuit, the sum of the quantities evolved, at the cold junction, and generated in the "resistance wire," is equal to the quantity absorbed on the whole in the other parts of the circuit. When there is an engine in the circuit, the sum of the heat evolved at the cold junction and the thermal equivalent of the weights raised, is equal to the quantity of heat absorbed on the whole in all the circuit except the cold junction.*

7. An application of the theory to the case of a circuit consisting of several different metals, shews that if

$$\varphi(A, B),\ \varphi(B, C),\ \varphi(C, D),\ \ldots\ \varphi(Z, A)$$

denote the electromotive forces in single elements, consisting respectively of different metals taken in order, with the same absolute temperatures of the junctions in each element, we have

$$\varphi(A, B) + \varphi(B, C) + \varphi(C, D) \ \ldots\ + \varphi(Z, A) = 0,$$

which expresses a proposition, the truth of which was first pointed out and experimentally verified by Becquerel. A curious experimental verification of this proposition (so far as regards the signs of the terms of the preceding equation) was made by the author, with reference to certain specimens of platinum wire, and iron and copper wires. He had observed that the platinum wire, with iron wires bent round its ends, constituted a less powerful thermo-electric element than an iron wire with copper wires bent round its ends, for temperatures within atmospheric limits. He tried, in consequence, the platinum wire with copper wires bent round its ends, and connected with the ends of a galvanometer coil; and he found that, with temperatures within atmospheric limits, a current passed from the copper to the platinum through the hot junction, and concluded that, in the thermo-electric series

$$\overset{+}{\text{Antimony}},\ \text{Iron},\ \left\{\begin{matrix}\text{Copper,}\\ \text{Platinum,}\end{matrix}\right\}\ \overset{-}{\text{Bismuth}},$$

this platinum wire must, at ordinary temperatures, be between iron and copper. He found that the platinum wire retained the same properties after having been heated to redness in a spirit-lamp and cooled again; but with temperatures above some limit itself considerably below that of boiling water, he found that the iron and platinum constituted a more powerful thermo-electric element than the iron and copper; and he verified that for such temperatures, in the platinum and copper element the current was from the platinum to the copper through the hot junction, and therefore that the copper now lay between the iron and the platinum of the series, or in the position in which other observers have generally found copper to lie with reference to platinum. A second somewhat thinner platinum wire was found to lie invariably on the negative side of copper, for all temperatures above the freezing point; but a third, still thinner, possessed the same property as the first, although in a less marked degree, as the superior limit of the range of temperatures for which it was positive towards copper was lower than in the case of the first wire. By making an element of the first and third platinum wire, it was found that the former was positive towards the latter, as was to be expected.

In conclusion, various objects of experimental research regarding thermo-electric forces and currents are pointed out, and methods of experimenting are suggested. It is pointed out that, failing direct data, the absolute value of the electromotive force in an element of copper and bismuth, with its two junctions kept at the temperatures 0° and 100° cent., may be estimated indirectly from Pouillet's comparison of the strength of the current it sends through a copper wire 20 metres long and 1 millimetre in diameter, with the strength of a current decomposing water at an observed rate; by means of determinations by Weber, and of others, of the specific resistance of copper and the electro-chemical equivalent of water, in absolute units. The specific resistances of different specimens of copper having been found to differ considerably from one another, it is impossible, without experiments on the individual wire used by M. Pouillet, to determine with much accuracy the absolute resistance of his circuit, but the author has estimated it on the hypothesis that the specific resistance of its substance is $2\frac{1}{4}$ British units. Taking ·02 as the electro-chemical equivalent of water in British absolute units, the author has thus found 16300 as the electromotive force of an element of copper and bismuth, with the two junctions at 0° and 100° respectively.

About 154 of such elements would be required to produce the same electromotive force as a single cell of Daniell's; if, in Daniell's battery, the whole chemical action were electrically efficient. A battery of 1000 copper and bismuth elements, with the two sets of junctions at 0° and 100° cent., employed to work a galvanic engine, if the resistance in the whole circuit be equivalent to that of a copper wire of about 100 feet long and about one-eighth of an inch in diameter, and if the engine be allowed to move at such a rate as by inductive reaction to diminish the strength of the current to the half of what it is when the engine is at rest, would produce mechanical effect at the rate of about one-fifth of a horse-power. The electromotive force of a copper and bismuth element, with its two junctions at 0° and 1°, being found by Pouillet to be about $\frac{1}{100}$ of the electromotive force when the junctions are at 0° and 100°, must be about 163. The value of Θ_0 for copper and bismuth, according to these results (and to the value 160·16 of μ at 0°), or the quantity of heat absorbed in a second of time by a current of unit strength in passing from bismuth to copper, when the temperature is kept at 0°, is $\frac{163}{160 \cdot 16}$, or very nearly equal to the quantity required to raise the temperature of a grain of water from 0° to 1° cent.

Monday, 5th January 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. On the Absolute Intensity of Interfering Light. By Professor Stokes. Communicated by Professor Kelland.

In this communication Professor Stokes described a method which he had discovered, by which he could express, mathematically, the absolute intensity of interfering light, as in the case of the images found in the focus of a telescope pointed to a star, and having a grating over the object-glass. The result was the same as that previously aimed at by Professor Kelland, but the mode of getting at it was shorter.

2. On Meconic Acid, and some of its Derivatives. By Mr Henry How. Communicated by Dr T. Anderson.

The author commenced his paper by observing that it formed a sequel to one communicated to the Society last Session on comenic acid; his object in the present instance having been partly to ascertain whether some of the substances described in his former paper could not be derived from meconic acid, which is the parent acid of comenic acid. This he shewed to be the case; but before detailing these experiments, he gave his process for purifying meconic acid, which is that of Gregory, modified by the use of ammonia instead of potass. Some grounds for preference of this plan were offered, and the composition of the salt obtained in the process was shewn to be

$$2\ NH_4O,\ HO,\ C_{14}\ HO_{11}.$$

It is a salt crystallising from hot water in groupes of needles; is not decomposed at the heat of boiling water by itself, but when kept long at this temperature, in presence of ammonia, it produces the comenamic acid,

$$HO,\ C_{12}\ H_4\ NO_7,$$

formerly described by the author as a product of the decomposition of comenate of ammonia in the same manner.

The action of chlorine on this salt gave rise, in the first place, to another acid salt of ammonia and meconic acid,

$$2\ HO,\ NH_4O,\ C_{14}\ HO_{11},$$

and, as a further product, chlorocomenic acid was isolated. Bromine gave with meconic acid bromocomenic acid; three experiments shewing that meconic acid itself yields no substitution products, its molecule splitting into carbonic acid, and the above-mentioned derivatives of comenic acid.

The action of hydrochloric acid gas on solution of meconic acid in alcohol was next gone into; and it appears that three products are formed, their relative proportions depending on the amount of gas employed, and the strength of the alcohol. They are all ethers. The first is the ethylomeconic acid, represented by the formula

$$2\ HO,\ C_4\ H_5O\ C_{14}\ HO_{11}.$$

It is a crystalline substance, soluble in water, alcohol, and ether; fusible at 316° Fahr. to a yellow fluid. It is possessed of acid properties, and is indeed bibasic, forming two series of salts; this was

shewn by the description and analyses of two acid salts, the baryta and silver salts, whose composition is thus expressed,

$$BaO, HO, C_4 H_5O C_{14} HO_{11}$$
$$AgO, HO, C_4 H_5O C_{14} HO_{11},$$

and a neutral baryta salt, of the constitution,

$$2 BaO, C_4 H_5O, C_{14} HO_{11}.$$

It was shewn that ethylomeconic acid undergoes a curious decomposition in contact with ammonia. It appears very complex; and Mr How gave, as representing the composition of the products he obtained, an ammonia salt of an amide acid, and the acid itself, the following formulæ,

$$\text{Ammonia salt } 9 NH_4O, C_{84} H_{24} N_7O_{63} + 3 \text{ aq.}$$
$$\text{Acid of } \ldots \quad 9 HO, C_{84} H_{24} N_7O_{63} + 3 \text{ aq.}$$

The acid appears to be formed by the grouping together of six atoms of normal amidomeconic acid and one of ammonia.

The second product of the action of hydrochloric acid gas upon meconic acid in alcohol was shewn to be an uncrystalline body, to which the formula, $C_{32} O_{12} O_{28}$, was assigned; and it was considered as formed from the coupling together of equivalents of meconic and ethylomeconic acids,

$$C_{32} H_{12} O_{28} = 3 HO, C_{14} HO_{11} + 2 HO, C_4 H_5O C_{14} HO_{11}$$

Want of substance prevented a complete study of this body; but it seems, from a few reactions tried, to be certainly more than a mere mixture of the two acids.

The third ether described was obtained from the mother liquors of the preceding two. The formula of this substance, biethylomeconic acid, is

$$HO, 2 C_4 H_5O C_{14} HO_{11},$$

it being meconic acid in which two atoms of basic water are replaced by two equivalents of ether. It is a crystalline substance, fusible in boiling water, in which it also dissolves on agitation. In the dry state it fuses at about 230° Fahr.

It is an acid, monobasic; an analysis was given of its ammonia and its baryta salt, their respective formulæ are

$$NH_4O, 2 C_4 H_5O, C_{14} HO_{11}$$
$$BaO, 2 C_4 H_5O, C_{14} HO_{11}.$$

Biethylomeconic acid is not decomposed by ammonia in the cold; but Mr How believes it undergoes a change when heated with this

alkali; want of material, however, prevented him arriving at a satisfactory conclusion on this point.

3. On the Place of the Poles of the Atmosphere. By Professor C. Piazzi Smyth.

This was merely a note on some of the recent discoveries and generalizations, by Lieut. Maury, U.S.N., on the motions of the atmosphere. It had been clearly proved by the extensive researches of Lieut. M., that the trade-winds when rising at the equator, do not, as previously held, return to their own poles, but cross over to the opposite ones; and thus traverse the extent of the whole earth from pole to pole, in a curvilinear direction, on account of the effect of the rotation of the earth. The whole atmosphere thus partakes of a general movement, the upper half moving towards the poles, and the lower towards the equator, or *vice versa,* according to the latitude of the place; the former occurring between the parallels of 0° and 30°, and the latter between 30° and 90°. At 0° and 30° two nodes, so to speak, of the upper and lower currents take place; at the former ascending, and indicated by a low barometer; at the latter descending, and marked by increased barometric pressure. At the point of 90°, the pole, or thereabouts, the revolution of the currents and their change of direction for N. and S., and *vice versa,* with another node, takes place, and marked, Lieut. Maury *thought,* by a *calm* region, as the two nodal zones of 0° and 30° most undoubtedly are.

As to the place of this calm polar point, which we shall probably long want observations to determine, Lieut. Maury did not place it over the poles of rotation of the world, but over the magnetical poles, without, however, as the present author thought, sufficient reason. Indeed, he much lamented that after the admirable developments made by Lieut. Maury of the motions of the atmosphere, he should have thus brought in merely the *name* of magnetism to clear up one obscure point. Meteorology pursued on the system of strict mechanical and scientific inquiry was now disclosing a most interesting and understandable series of phenomena, and promised a legitimate harvest of more. But the history of this science in times past, points to so many occasions when rational trains of observation were impeded by the gratuitous introduction of a magnetic or electric element, and thought to be needless thereafter, that the author supposed that it might be of some service to shew that there was no probability in

the present case, either from actual observation or natural considerations, that such a force should be looked to for explanation.

1*st*, Of actual observation. The poles of any force should bear a certain known relation to the equator thereof; and if we find the magnetic equator coincident with that of the atmosphere, which may be considered as marked out by the line of equatorial calms, we might reasonably suppose a connection between their poles. But we do not. The mean positions of these equators are very different from each other, and are subject to such totally different movements through the year, that we cannot legitimately expect any nearer coincidence in their polar points.

2*d*, Of natural considerations. Mechanical force may always be taken as the cause, and not as the consequence, of the magnetic or electric currents by which it is accompanied. Certainly in the case of an electrical machine, the electric spark may be made to produce mechanical energy, as shewn in knocking small light pith balls about; but how incomparably less is this force to that employed to turn the machine round in the first instance to produce the electricity.

Now, the atmosphere enveloping and rubbing over the world, may be taken as a large electrical machine, and does produce electric and magnetic forces; but these, although startling enough when witnessed by us, little pigmies of men, are of infinitely small moment compared to the force required to keep the whole atmosphere in motion, and to overcome its friction and inertia.

Again, with regard to the intensity of terrestrial magnetism, it is found with one of Gauss's large bars for determining the horizontal force, by being suspended by two wires separated in the direction of its axis, that the whole magnetic force amounts to less than 100,000th part of the weight of the bar, that is, the force or attraction of gravity.

Similar experiments might be adduced, to shew that when a body is heated, though electrical currents may be produced, and may have a certain mechanical power, that yet the quantity of this is almost infinitely small compared to what might be produced by employing the heat directly.

Hence, there can be no reasonable doubt, that the principal movements of the atmosphere must be owing to mechanical and thermotic causes, and only the smaller features to electric and magnetic currents.

A parallel case of the proneness of men to run for an explanation

to magnetism, occurred in the early history of the development of the *law of storms*, and has not yet, so far as I am aware, been distinctly refuted by the public, or withdrawn by its promulgator.

In Colonel Reid's first work (1838) on the revolving motion of the hurricanes, after having, in the earlier portion, detailed, in the most satisfactory manner, the *laws of the phenomena*, he gives, in the latter portion, a glimpse of a *theory* of them, or at least, details an experiment in which, on the surface of a magnetised iron shell representing the earth, a rotation in opposite directions was produced in helices in either hemisphere of the ball. This was thought *very interesting*, as the hurricanes are found to revolve in opposite directions in either half of the world; and it was further stated that in St Helena, where the magnetic intensity is small, hurricanes are unknown; while in the West Indies, where hurricanes are so rife, the magnetic intensity is at a maximum.

Here, it will be observed, is no attempt to shew whether the magnetic power is *sufficient* to cause the observed effect, or has any power in that way at all, nor even to trace whether this particular coincidence at two points, in the tropical belt of the earth, prevailed at all others also; and in the Colonel's last publication (1848) the question and the experiment are withdrawn altogether.

When, however, we examine the subject more extensively, we find a pretty general rule to prevail all round the world, viz., that hurricanes are most frequent in the western parts of those seas where the trade-wind is suddenly stopped by the occurrence of land, and is unknown in the eastern parts of the seas where it begins. Thus, not only is the placid climate of St Helena fully accounted for by being in the eastern position of the South Atlantic, but equally the similar freedom from revolving storms of the Cape De Verde Islands, the NW. and SW. coast of Africa, with California and Peru on the eastern shores of the Pacific.

And again, while the West Indies are pointed out as *likely* places for hurricanes, so are Rio Janeiro, Canton, the Mauritius, and Madras, and, in fact, almost every place where hurricanes have been met with.

The stoppage, then, and interference of the trade-wind, a purely mechanical question, is the cause of the hurricanes, and, according to the greater or less force of the trade-wind, and the greater quantity of air struggling to get over the barrier, as observed in the case of water when a river is in a flood, or on a sea-coast at spring-tide,

so are more numerous and more violent eddies found, and they revolve in different directions in either hemisphere, because the direction of the parent trade-wind is also different in each.*

These mechanical causes, we may be certain, are acting, and must have the chief share in the effects which we observe, and should therefore be followed out in all their consequenees, before we attempt to introduce any problematical forces which cannot possibly have much, if they have indeed any effect.

The following Donations to the Library were announced :—

Flora Batava. Aflevering 166. 4to.—*From the King of the Netherlands.*

Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. Sciences Mathématiques, Physiques et Naturelles. Tome IVme, Liv. 3 & 4. 4to.

Mémoires présentés à l'Académie Impériale des Sciences de St Pétersbourg, par divers Savants, et lus dans ses Assemblées. Tome VIme. Liv. 5 & 6. 4to.—*From the Academy.*

Memorie della Reale Accademia della Scienze di Torino. Serie Seconda. Tomo XI. 4to.—*From the Academy.*

Annales de l'Observatoire Physique Central de Russie. 1848. 3 tom. 4to.—*From the Observatory.*

Compte Rendu Annuel, Addressé à M. le Comte Wrontchenko, Ministre des Finances, par le Directeur de l'Observatoire Physique Central de Russie, A. T. Kupffer. 1850. 4to.—*From the Editor.*

The American Journal of Science and Arts. Vol. XII., No. 36. 8vo.—*From the Editors.*

Bulletin de la Société de Géographie. 4me Serie. Tom. I. 8vo.—*From the Society.*

* I have just met with an, at first sight, anomalous instance, in the account of a circular storm experienced by the American exploring expedition under Captain Wilkes in the neighbourhood of the Cape De Verd Islands, a similar latitude to the West Indies, but on the "wrong" side of the Atlantic, and moreover revolving *with* the hands of a watch, "wrong" also. But the *parent* wind in this case is described to have been *SE.*, which explains everything; and shews that the whole phenomenon is an affair of mechanical conditions in the currents of air at the place; that these being reversed, the hurricane phenomena are reversed also, and that there is no magnetic or other virtue residing in either hemisphere, and compelling air to circulate in any particular direction by reason of its *place*.

Abhandlungen der Königliche Akademie der Wissenschaften zu Berlin. 1849. 4to.

Monatsbericht der Königliche Akademie der Wissenschaften zu Berlin. 1850, Jan. — Dec.; 1851, Jan. — Juni. 8vo.—*From the Academy.*

Proceedings of the Philosophical Society of Glasgow. 1850. Vol. III., No. 3. 8vo.—*From the Society.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1850, Nos. 3 & 4; 1851, No. 1. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. 1851. No. 5. 8vo.—*From the Society.*

Monday, 19*th January* 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. Defence of the Doctrine of Vital Affinity, against the objections stated to it by Humboldt and Dr Daubeny. By Dr Alison.

The object of this paper was to fix attention on the great physiological discovery which has been gradually effected during the present century, of the mode in which certain of the elements contained in the earth's atmosphere, under the influence of light and of a certain temperature, are continually employed in maintaining that great vital circulation, of which vegetable structures, animal structures, the air, and the soil, are the successive links; and to point out that the most essential and fundamental of the changes here effected,—particularly the formation of the different organic compounds in the cells of vegetables,—are strictly *chemical changes*, at least as clearly distinct from any chemical actions yet known to take place in inorganic matters, as the vital contractions of muscles are distinct from any merely mechanical causes of motion; and justifying the statement of Dr Daubeny, that there appears to be "a power, residing in living matters" and producing chemical effects,—in fact manifesting itself most unequivocally by the chemical changes which result from it,—"distinct, at least in its effects, from ordinary chemical and physical forces."

But after having made this statement, Dr Daubeny, according to the author of this paper, has thrown a degree of mystery over the subject which is quite unnecessary and even unphilosophical, by refusing to admit—and quoting Humboldt, who has changed his opinion on the subject, and now likewise declines to admit—that these changes are to be regarded as *vital;* both authors (as well as several other recent English authors) maintaining, that as we do not know all the conditions under which ordinary chemical affinities act in living bodies, we are not entitled to assert that these affinities may not yet be found adequate to the production of all the chemical changes which living bodies present; and that until this *negative proposition* is proved, it is unphilosophical and delusive to suppose the existence of any such power, as that to which the term Vital Affinity has been applied, by the author of this paper and several other physiologists.

In answer to this, it is here stated, that as we cannot, strictly speaking, *define* Life or Vitality, we follow the strict rules of philosophy, in *describing* what we call living bodies, whether vegetable or animal, and then applying the term Vital or living, as the general expression for everything which is observed to take place only in them, and which is inexplicable by the physical laws, deduced from the observation of the other phenomena of nature; that according to this,—the only definition of which the term *vital* admits, or by which the objects of Physiology can be defined,—Dr Daubeny has already admitted, in the expressions above quoted from him, that chemical as well as mechanical changes in living bodies, fall under the denomination *vital;* and as the rule of sound logic is "*affirmantibus* incumbit probatio,"—and as it is just as probable *a priori*, that, with a view to the great objects of the introduction of living beings upon earth, the laws of chemistry, as those of mechanics, should be modified or suspended by Almighty Power,—this author maintains that we are as fully justified in referring all great essential chemical phenomena, which are peculiar to living bodies, to peculiar affinities, which we term vital, as Haller was to ascribe the peculiar mechanical movements of living bodies, to the vital property of Irritability; and to throw on the mechanical physiologists of his day the burden of proving, if they could, that the laws of motion, perceived in dead matter, were adequate to explain them.

In illustration of the importance, both in Physiology and Pathology, of this principle being held to be established, Dr Alison ad-

duced two examples, *first*, the utter failure of the very ingenious theory of Dr Murray to explain, on ordinary chemical principles, the simplest and most essential phenomena of healthy Secretion; and, *secondly*, the now generally admitted inadequacy of any theory of Inflammation, which does not regard a modification of the *affinities* peculiar to life, and here termed vital, as the primary and essential change, in the matter concerned in that process.

2. On the Fatty Acid of the Cocculus Indicus. By Mr William Crowder. Communicated by Dr Anderson.

The following Gentlemen were duly elected as Ordinary Fellows:—

1. Eyre B. Powell, Esq., Madras.
2. Thomas Miller, Esq., Rector, Perth Academy.
3. Allen Dalzell, Esq.

Monday, 2d February 1852.

Sir DAVID BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read:—

1. On the Function of the Spleen and other Lymphatic Glands, as originators of the Corpuscular Constituents of the Blood. By Dr Bennett.

The author had been enabled to study the blood corpuscles under circumstances capable of extending our information with regard to their relations, mode of formation, and ultimate destination. In 1845, he had discovered a peculiar condition in human blood, in which the colourless cells were greatly increased in number. This condition he had called leucocythemia, which was always associated with enlargement of the spleen or other lymphatic glands, a circumstance which had induced him to form the opinion that the corpuscles of the blood originated in these organs. This view he sought to establish by discussing at considerable length the following questions, viz.:—1*st*, What relation do the colourless and coloured corpuscles bear to each other? 2*d*, Where do they originate? 3*d*, What is their ultimate destination?

From the whole inquiry, which included numerous observations on

the blood of vertebral animals, careful investigations into the structure of the ductless glands, and several experiments, he deduced the following conclusions :—

1. That the blood corpuscles of vertebrate animals are originally formed in the lymphatic glandular system, and that the great majority of them on joining the circulation, become coloured in a manner that is as yet unexplained. Hence, the blood may be considered as a secretion from the lymphatic glands, although in the higher animals that secretion only becomes fully formed after it has received colour by exposure to oxygen in the lungs.

2. That in the mammalia, the lymphatic glandular system is composed of the spleen, thymus, thyroid, supra-renal, pituitary, pineal, and lymphatic glands.

3. That in fishes, reptiles, and birds, the coloured blood corpuscles are nucleated cells originating in these glands, but that in mammals, they are free nuclei, sometimes derived as such from the glands, at others, developed within colourless cells.

4. That in certain hypertrophies of the lymphatic glands, their cell elements are proportionally increased in number, and under such circumstances the colourless cells of the blood are also proportionally increased. This is Leucocythemia.

5. That the solution of the corpuscles of the blood, conjoined with the effete matter derived from the tissues, which is not converted into albumen, constitute blood fibrin.

2. On the Mechanical action of Radiant Heat or Light: On the Power of Animated Creatures over Matter: On the Sources available to Man for the production of Mechanical Effect. By Professor William Thomson.

On the Mechanical Action of Radiant Heat or Light.

It is assumed in this communication that the undulatory theory of radiant heat and light, according to which light is merely radiant heat, of which the vibrations are performed in periods between certain limits of duration, is true. "The chemical rays," beyond the violet end of the spectrum, consist of undulations of which the full vibrations are executed in periods shorter than those of the extreme visible violet light, or than about the eight hundred million millionth

of a second. The periods of the vibrations of visible light lie between this limit and another, about double as great, corresponding to the extreme visible red light. The vibrations of the obscure radiant heat beyond the red end are executed in longer periods than this; the longest which has yet been experimentally tested being about the eighty million millionth of a second.

The elevation of temperature produced in a body by the incidence of radiant heat upon it is a mechanical effect of the dynamical kind, since the communication of heat to a body is merely the excitation or the augmentation of certain motions among its particles. According to Pouillet's estimate of heat radiated from the sun in any time, and Joule's mechanical equivalent of a thermal unit, it appears that the mechanical value of the solar heat incident perpendicularly on a square foot above the earth's atmosphere is about eighty-four foot-pounds per second.

Mechanical effect of the statical kind might be produced from the solar radiant heat, by using it as the source of heat in a thermo-dynamic engine. It is estimated that about 556 foot-pounds per second of ordinary mechanical effect, or about the work of "one horse power," might possibly be produced by such an engine exposing 1800 square feet to receive solar heat, during a warm summer day in this country; but the dimensions of the moveable parts of the engine would necessarily be so great as to occasion practical difficulties in the way of using it with economical advantage that might be insurmountable.

The *chemical* effects of light belong to the class of mechanical effects of the statical kind; and reasoning analogous to that introduced and experimentally verified in the case of electrolysis by Joule, leads to the conclusion that when such effects are produced there will be a loss of heating effect in the radiant heat or light which is absorbed by the body acted on, to an extent thermally equivalent to the mechanical value of the work done against forces of chemical affinity.

The deoxidation of carbon and hydrogen from carbonic acid and water, effected by the action of solar light on the green parts of plants, is (as the author recently found was pointed out by Helmholz* in 1847), a mechanical effect of radiant heat. In virtue of this action

---

* "Ueber die Erhaltung der Kraft, von Dr H. Helmholz." Berlin, 1847.

combustible substances are produced by plants; and its mechanical value is to be estimated by determining the heat evolved by burning them, and multiplying by the mechanical equivalent of the thermal unit. Taking, from Liebig's Agricultural Chemistry, the estimate 2600 pounds of dry fir wood for the annual produce of one Hessian acre, or 26,910 square feet, of forest land, (which in mechanical value appears not to differ much from estimates given in the same treatise for produce of various kinds obtained from *cultivated* land,) and asuming, as a very rough estimate, 4000 thermal units centigrade as the heat of combustion of unity of mass of dry fir wood; the author finds 550,000 foot-pounds (or the work of a horse-power, for 1000 seconds), as the mechanical value of the mean annual produce of a square foot of the land. Taking 50° 34′ (that of Giessen,) as the latitude of the locality, the author estimates the mechanical value of the solar heat which, were none of it absorbed by the atmosphere, would fall annually on each square foot of the land, at 530,000,000 foot-pounds; and infers that probably a good deal more, $\frac{1}{1000}$ of the solar heat, which actually falls on growing plants, is converted into mechanical effect.

When the vibrations of light thus act during the growth of plants, to separate, against forces of chemical affinity, combustible materials from oxygen, they must lose *vis viva* to an extent equivalent to the statical mechanical effect thus produced; and therefore quantities of solar heat are actually put out of existence by the growth of plants, but an equivalent of statical mechanical effect is stored up in the organic products, and may be reproduced as heat, by burning them. All the heat of fires, obtained by burning wood grown from year to year, is in fact solar heat reproduced.

The actual convertibility of radiant heat into statical mechanical effect, by inanimate material agency, is considered in this paper as subject to Carnot's principle; and a possible connection of this principle with the circumstances regarding the quality of the radiant heat (or the colour of the light), required to produce the growth of plants, is suggested.

On the Power of Animated Creatures over Matter.

The question, "Can animated creatures set matter in motion in virtue of an inherent power of producing mechanical effect?" must be answered in the negative, according to the well-established theory

of animal heat and motion, which ascribes them to the chemical action (principally *oxidation*, or a combustion at low temperatures), experienced by the food. A principal object of the present communication is to point out the relation of this theory to the dynamical theory of heat. It is remarked, in the first place, that both animal heat and weights raised or resistance overcome, are *mechanical* effects of the chemical forces which act during the combination of food with oxygen. The former is a dynamical mechanical effect, being thermal motions excited; the latter is a mechanical effect of the statical kind. The whole mechanical value of these effects, which are produced by means of the animal mechanism in any time, must be equal to the mechanical value of the work done by the chemical forces. Hence, when an animal is going uphill or working against resisting force, there is less heat generated than the amount due to the oxidation of the food, by the thermal equivalent of the mechanical effect produced. From an estimate made by Mr Joule, it appears that from $\frac{1}{4}$ to $\frac{1}{5}$ of the mechanical equivalent of the complete oxidation of all the food consumed by a horse may be produced, from day to day, as weights raised. The oxidation of the whole food consumed being, in reality, far from complete, it follows that a less proportion than $\frac{4}{5}$, perhaps even less than $\frac{3}{4}$, of the heat due to the whole chemical action that actually goes on in the body of the animal, is given out as heat. An estimate, according to the same principle, upon very imperfect data, however, is made by the author, regarding the relation between the thermal and the nonthermal mechanical effects produced by a man at work; by which it appears that probably as much as $\frac{1}{6}$ of the whole work of the chemical forces arising from the oxidation of his food during the 24 hours, may be directed to raising his own weight, by a man walking up-hill for 8 hours a-day; and perhaps even as much as $\frac{1}{4}$ of the work of the chemical forces, may be directed to the overcoming of external resistances by a man exerting himself for 6 hours a-day in such operations as pumping. In the former case there would be not more than $\frac{5}{6}$, and in the latter not more than $\frac{3}{4}$ of the thermal equivalent of the chemical action emitted as animal heat, on the whole, during the 24 hours, and the quantities of heat emitted during the times of working would bear much smaller proportions respectively than these, to the thermal equivalents of the chemical forces actually operating during those times.

A curious inference is pointed out, that an animal would be sensibly less warm in going up-hill than in going down-hill, were the breathing not greater in the former case than in the latter.

The application of Carnot's principle, and of Joule's discoveries regarding the heat of electrolysis and the calorific effects of magneto-electricity, is pointed out; according to which it appears nearly certain that, when an animal works against resisting force, there is not a *conversion of heat into external mechanical effect*, but the full thermal equivalent of the chemical forces is *never produced;* in other words that the animal body does not act as a *thermo-dynamic engine;* and very probable that the chemical forces produce the external mechanical effects through electrical means.

Certainty regarding the means in the animal body by which external mechanical effects are produced from chemical forces acting internally, cannot be arrived at without more experiment and observation than has yet been applied; but the relation of mechanical equivalence, between the work done by the chemical forces, and the final mechanical effects produced, whether solely heat, or partly heat and partly resistance overcome, may be asserted with confidence. Whatever be tho nature of these means, consciousness teaches every individual that they are, to some extent, subject to the direction of his will. It appears, therefore, that animated creatures have the power of immediately applying, to certain moving particles of matter within their bodies, forces by which the motions of these particles are directed to produce desired mechanical effects.

On the Sources available to Man for the Production of Mechanical Effect.

Men can obtain mechanical effect for their own purposes either by working mechanically themselves, and directing other animals to work for them, or by using natural heat, the gravitation of descending solid masses, the natural motions of water and air, and the heat, or galvanic currents, or other mechanical effects produced by chemical combination, but in no other way at present known. Hence the stores from which mechanical effect may be drawn by man belong to one or other of the following classes:—

I. The food of animals.

II. Natural heat.

III. Solid matter found in elevated positions.

IV. The natural motions of water and air.

V. Natural combustibles (as wood, coal, coal-gas, oils, marsh gas, diamond, native sulphur, native metals, meteoric iron.)

VI. Artificial combustibles (as smelted or electrolytically-deposited metals, hydrogen, phosphorus.)

In the present communication, known facts in natural history and physical science, with reference to the sources from which these stores have derived their mechanical energies, are adduced to establish the following general conclusions:—

1. *Heat radiated from the sun* (sunlight being included in this term) *is the principal source of mechanical effect available to man.** From it is derived the whole mechanical effect obtained by means of animals working, water-wheels worked by rivers, steam-engines, and galvanic engines, and part at least of the mechanical effect obtained by means of windmills and the sails of ships not driven by the trade-winds.

2. The motions of the earth, moon, and sun, and their mutual attractions, constitute an important source of available mechanical effect. From them all, but chiefly, no doubt, from the earth's motion of rotation, is derived the mechanical effect of water-wheels driven by the tides. The mechanical effect so largely used in the sailing of ships by the trade-winds is derived partly, perhaps principally, from the earth's motion of rotation, and partly from solar heat.

3. The other known sources of mechanical effect available to man are either terrestrial—that is, belonging to the earth, and available without the influence of any external body,—or meteoric,—that is, belonging to bodies deposited on the earth from external space. Terrestrial sources, including mountain quarries and mines, the heat of hot springs, and the combustion of native sulphur, perhaps also the combustion of all inorganic native combustibles, are actually used, but the mechanical effect obtained from them is very inconsiderable, compared with that which is obtained from sources belonging to the two classes mentioned above. Meteoric sources, including only the heat of newly-fallen meteoric bodies, and the combustion of meteoric iron, need not be reckoned among those available to man for practical purposes.

* A general conclusion equivalent to this was published by Sir John Herschel in 1833.—See his *Astronomy*, edit. 1849, § (399.)

The following Gentleman was duly elected an Ordinary Fellow :—

Dr JOHN WYLIE, late Physician-General, Madras.

The following Donations to the Library were announced :—

Smithsonian Contributions to Knowledge. Vol. II. Collection of Various Reports. 4to.—*From the Smithsonian Society.*

Transactions of the Zoological Society of London. Vol. IV., Pt. 1. 4to.

Proceedings of the Zoological Society of London. Nos. 201–213. 8vo.

Proceedings of the American Association for the Advancement of Science. August 1850. 8vo.—*From the Association.*

Transactions of the Horticultural Society of London. 2d Series. Vol. II., Pts. 3, 4, 5, 6; Vol. III., Pts. 1, 2, 3. *From the Society.*

Novi Commentarii Academiæ Scientiarum Instituti Bononensis. Tom. VI., VII., VIII., IX., X. 4to.—*From the Academy.*

Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo I. 4to.—*From the Academy.*

Monday, 16*th February* 1852.

MR RUSSEL in the Chair.

The following Communications were read :—

1. On some improvements in the instruments of Nautical Astronomy. By Professor C. Piazzi Smyth.

The excessive motion of a ship at sea renders the use of the ordinary instruments employed on land impossible, and restricts the sailors to the use of one on the principle of the duplication of images discovered by Hadly.

The favourite form is at present, and has always been, that of a quadrant or sextant, *i.e.*, a part of a circle, rather than a whole one, though this has often been brought forward by scientific men, and proved to be the most accurate : but the construction of these circles was generally too complicated, and practically unsuited to the circumstances usually met with at sea.

Taking the best of the sextants, then, as the form generally found in actual use, the author shewed that it laboured under many disad-

vantages, some peculiarly its own, others shared in common with the circular variety of doubly-reflecting instruments; and that, in a word, they were all, though convenient enough for day observations of the sun and moon, extremely inconvenient for, if not altogether incapable of, observations of the stars at night.

The author then pointed out, in some instruments exhibited, their various imperfections, explaining the cause, and giving the mode of removing them; and finally produced a new description of circle, in which he had had all the above-mentioned imperfections corrected.

The execution of the idea had been entrusted to Mr John Adie, and had been performed so efficiently, that the author considered that his best thanks were due to Mr Adie, who had thus most materially assisted the carrying out of the original ideas.

2. Notice of an Antique Marble Bust (with Photographs). By Andrew Coventry, Esq.

Mr Coventry read a short notice of an antique marble bust which he had had the good fortune to purchase from a gentleman in Westmoreland, last autumn, and had reason to believe had been brought from Italy.

The bust, of which some very fine photographs were exhibited (executed by Mr Tunny of Newington, and Captain Scott, R.N.), Mr Coventry considered to be a portrait, and a work of high Greek art. On various grounds, but chiefly from its great resemblance to the busts of the young Augustus:—from the hair being treated in the method in use in his day and soon after abandoned; and from the accordance of the features with the known history and character of Octavia, the sister of Augustus, Mr Coventry was disposed at first to think it the bust of that celebrated personage. But he deferred to an opinion which he had received by that day's post from Mr Burgon of the British Museum, that it was the bust of Antonia Augusta, Octavia's second daughter by Marc Antony, in honour of whom coins had been struck by her son Claudius. Mr Burgon's opinion rested on the authority of those coins, which were inscribed with her name and bore the strongest resemblance to the photographs Mr Coventry had forwarded to him from his bust.

3. Note on a Method of procuring very rapid Photographs (with Specimens). By John Stuart, Esq.

The following method of taking collodion portraits and views, is so easy in manipulation, and so rapid in its results, that it is worthy of the notice of every lover of photography. By means of an apparatus adjusted to the lens of the camera, so as to open and close it instantaneously, views can be taken with sufficient rapidity to delineate vehicles in motion, assemblies of people, and even the waves of the sea.

It also produces a picture combining both the positive and negative on the same plate; the positive being shewn by a reflected, and the negative by a transmitted light. Copies on paper can be thrown off from these plates to any extent; but this is a difficult operation, as any daylight, unless *very carefully* subdued, proves too strong. The process is as follows:—A plate of glass perfectly clean on the surface, and free from moisture, is coated with collodion, made as under. It is then plunged into a bath of nitrate of silver in solution (distilled water), 45 grs. to the oz. for sunlight, (100 *grs. to the oz. for portraits to be taken instantaneously in a room*), and allowed to remain till an oily appearance on the plate disappears. The plate is then fit for the camera, and will remain sensitive for twelve hours, or probably longer. After the view is taken, develop the picture with a solution of the sulphate of iron (20 grs. to the oz.) slightly heated, and fix it (after washing) with a saturated solution of hyposulphate of soda. The plate when dry, must be kept some days, and then varnished with a very thin solution of Canada varnish in spirits of turpentine. Previous to varnishing, the picture should be brushed over with a camel-hair brush, which adds much to its beauty and clearness. In a very *dull light* (but out of doors), the above proportion, 45 grs. nitrate silver, will take portraits and views, under ten seconds most distinctly, and unless the opening and shutting of the camera be very quick, better pictures can be produced thus than those taken instantaneously in strong sunlight. The collodion found best to suit this process is made as under.—By weight sixty parts of pounded nitre, forty of rectified sulphuric acid, and two of sea island cotton. The cotton must remain three minutes in the mixture, and then be dried and dissolved in ether along with as much

of the precipitate of nitrate of silver by iodide of potassium as it will absorb. The collodian should be very thin and as transparent as water.

The following Gentleman was duly elected an Ordinary Fellow.

JAMES CUNNINGHAM, Esq., W.S.

The following Donations to the Library were announced :—

Verhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. 4to.—*From the Academy.*

Journal of the Horticultural Society of London. Vol. VII., Part 1. 8vo.—*From the Society.*

Museum of Practical Geology :—On the Science of Geology and its applications. By Andrew C. Ramsay ;—On the value of extended knowledge of Mineralogy and the Process of Mining. By W. W. Smyth ;—On the Importance of Special Scientific Knowledge. By John Percy, M.D. 8vo.—*From the Museum.*

Monday, 1st March 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read :—

1. On some Salts and products of Decomposition of Pyromeconic Acid. By Mr James F. Brown. Communicated by Dr Anderson.

The pyromeconic acid employed in the following experiments was obtained by distilling impure meconic acid at a temperature of about 500° or 600° Fahr., when there is obtained a highly crystalline sublimate of a dark colour and empyreumatic odour. Its purification was effected by pressing the crystals so procured between folds of filtering paper, and finally subliming them at a moderate heat in cylindrical glass vessels provided with paper diaphragms. As thus

obtained, it is in the form of beautiful large transparent plates, of ready solubility in water and alcohol. It is also soluble in ether, reddens litmus faintly, and is completely volatile at 212°, a property which may serve as a test of its purity from paracomenic acid, that acid requiring a much higher temperature for its sublimation. Several attempts were made to prepare the ammonia and potash salts of this acid, but without success.

The acid gave on analysis per-centage results agreeing with the formula $C_{10}\ H_3\ O_5\ +\ H\ O$, which is that hitherto adopted.

Pyromeconate of baryta, $Ba\ O,\ C_{10}\ H_3\ O_5\ +H\ O$, precipitates as small colourless silky needles, when a warm ammoniacal solution of pyromeconic acid is mixed with acetate of baryta. By evaporation *in vacuo*, it crystallises in four-sided prisms of a yellow colour. It is the most soluble in water of all the earthy salts of this acid, 100 parts of water at 60° dissolving 2·50 parts of the salt.

Pyromeconate of strontia, $Sr\ O,\ C_{10}\ H_3\ O_5+H\ O$. This salt may be obtained by mixing alcoholic solutions of the acid with ammonia and nitrate of strontia, when there ensues an immediate precipitate of the salt in small colourless crystals, of sparing solubility in water and alcohol, 100 parts of the former at 68° dissolving 1·3 parts.

Pyromeconate of lime, $Ca\ O\ C_{10}\ H_3\ O_5+H\ O$. This salt was prepared in a manner similar to that of the two preceding. It is soluble in water and alcohol to a small extent, 100 parts of the former at 68°, dissolving 0·31 of the salt.

Pyromeconate of magnesia, $Mg\ O\ C_{10}\ H_3\ O_5$, falls as an amorphous powder, when acetate of magnesia is added to an ammoniacal solution of pyromeconic acid.

The pyromeconates of lead, copper, and iron, have already been examined, and I merely repeated their analysis, to confirm the formulæ which have been given for them.

The products of decomposition of this acid were next examined, cold nitric acid of sp. gr. 1·4 decomposes it with the evolution of nitrous acid gas, and production of oxalic and hydrocyanic acids. Sulphuric in the cold has no action on pyromeconic acid, but when gently warmed, it dissolves to a colourless fluid, which, upon cooling, deposits the acid again. I failed, however, in procuring an ether or a chlorine substitution product of this acid.

Bromopyromeconic acid, $C_{10}\ H_2\ Br\ O_5\ +\ H\ O$, is obtained in the form of beautiful small colourless prisms, when bromine water

is made to react on excess of pyromeconic acid. These crystals are slightly soluble in water, but readily so in boiling alcohol, they redden litmus faintly, and impart to persalts of iron a deep purple colour, quite distinct from the red produced by the original acid. Nitrate of silver causes no precipitate in solutions of this acid; neither when boiled does it reduce the oxide to the metallic state. Submitted to destructive distillation it fuses, and then blackens; hydrobromic acid is evolved in large quantity; and after some time a white crystalline sublimate makes its appearance, but in quantity too small to admit of examination.

Bromopyromeconate of lead, $Pb\ O\ C_{10}\ H_2\ Br.\ O_5 + H\ O$, is precipitated as small dense crystalline grains, when warm alcoholic solutions of the acid and acetate of lead are mixed together.

2. On the Organs in which Lead accumulates in the Horse, in cases of slow poisoning by that Metal. By Dr George Wilson.

The chief object of this paper was to state the result of a careful analysis of the viscera of a mare, which had died after receiving daily, for six weeks or more, carbonate of lead in its food and drink. Portions of the lungs, the heart, the large intestine and its contents, the stomach and duodenum, the spleen, the kidney, and the liver, were subjected to analysis by the author, assisted by Mr Stevenson Macadam.

As the quantity of animal matter was large, it became a question what preliminary process should be followed, with a view to facilitate the final charring to which each organ must be subjected. Sulphuric acid was rejected on account of its liability to contain lead, and the certainty of its forming an insoluble compound with the lead it might encounter in the tissues. Nitric acid had been found in previous trials to act too slowly; and a mixture of chlorate of potass and hydrochloric acid left too large a residue of saline matter, to seem applicable. Aqua regia, accordingly, which has been recommended in such cases by the French chemists, was tried, and was found to answer every expectation.

Each of the organs was digested in a mixture of one part of nitric acid and two of hydrochloric acid, which dissolved everything but the fat. The resulting solution was evaporated to dryness, the resi-

due charred, digested in nitric acid, and the acid solution filtered and exposed to a stream of sulphuretted hydrogen. A dark precipitate was obtained which was dissolved in dilute nitric acid, evaporated to dryness and redissolved in water, acidulated with hydrochloric acid. This solution was tested with sulphuretted hydrogen, sulphuric acid, iodide of potassium, and bichromate of potass, and acted characteristically with all the tests. The spleen yielded the fullest indications of the presence of lead, the liver came next in shewing indications of the metal, then the lungs, afterwards the kidneys, and lowest of all, the intestinal canal.

It would thus appear, that, in the case under notice, the spleen and not the liver was the organ in which lead occurred most abundantly. The author, accordingly, suggests that the spleen rather than the liver should be the organ subjected to analysis in cases of suspected slow poisoning with lead; at least, where a single organ only is analysed.

3. Notice regarding the occurrence of Pumice in the Island of Tyree. By The Duke of Argyll.

The Duke of Argyll (in connection with other evidences of a more conclusive kind, that, during some portion of the tertiary ages, there had been some subaerial volcanic action in the Hebrides) explained the mode in which pumice occurred in the Island of Tyree. The pumice was found to form a bed or layer along the line of an ancient sea-beach, and was in the shape of balls more or less closely packed together. These appearances seemed to indicate that they had come in on the waters of a tide or current in large numbers at a time. They were manifestly sea-borne; and the only question was as to the most probable source. The bay and general line of coast on which they are found is not that which is opposed to the modern current of the Gulf Stream; but, on the contrary, looks eastward, that is to say, towards the trap Islands of Mull, Staffa, &c.

The author considered it improbable that the origin of the pumice could have been very distant, inasmuch as the greater the distance, the greater would be the dispersion of such light floating bodies by winds and currents; and it was difficult to suppose that either from the West Indies or from Iceland, pumice could have concentrated in such quantities on such a spot. Its presence, however, and its deposition, in the manner described, could be easily accounted for, if

any portion of the traps of Mull, Staffa, or the adjacent islets, were poured out by a subaerial volcano; and these the author considered as placed almost beyond dispute, by the facts brought to light in connection with the tertiary leaf-beds, overflown by lavas, at the opposite headland of Ardtan, in Mull.

4. Recent Observations on the direction of the Striæ on Rocks and Boulders. By James Smith, Esq.

Mr Smith of Jordanhill next read a paper on the direction of the striæ on rocks and boulders in the West of Scotland.

It had generally been supposed that the cause, whatever it was, which lodged the erratic block beds in their present position had proceeded from the north and west.

This was true with respect to the basin of the Clyde and the east coast of Scotland; but on the western coast of Argyllshire, at Loch Crinan and Appin he had observed that the strike side (stoss seite) of the rocks pointed to the east, and the lee side (lee seite) to the west, shewing that, in these cases, the direction of the moving force was from east to west. Mr Hopkins' recent observations on the direction from which boulders near Oban have been derived, shewed that they also must have come in the same direction.

Mr Smith then observed the occurrence of a large angular granite block on the shore at Helensburgh, which apparently must have been transported over ice. He had also observed at the Island of Cumbra an angular mass of trap, resting on a scratched rock, and split vertically into several pieces; he had observed blocks split in the same manner, which had fallen from the terminus of the glacier of Grindelwald.

The following Donations to the Library were announced:—

Philosophical Transactions of the Royal Society of London. 1851. Part 2. 4to.

List of Fellows of Do. 30th Nov. 1851. 4to.—*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. XX. 4to.

Notices of Do. Vol. II. 1850-1. Nos. 1-9. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society. Vol. VIII., Part 1. 8vo.—*From the Society.*

American Journal of Science and Arts. Vol. XIII., No. 37. 8vo. —*From the Editors.*

Transactions of the Royal Scottish Society of Arts. Vol. III., Part 5. 8vo.—*From the Society.*

Transactions of the Architectural Institute of Scotland. Vol. II., Part 2. 8vo.—*From the Institute.*

Journal of Agriculture; and Transactions of the Highland and Agricultural Society of Scotland. N.S. No. 36. 8vo.—*From the Society.*

Astronomical and Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1850. 4to. —*From the Royal Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathemat. Natur. Classe. Bd. VII., Stück 1 & 2. 8vo.—*From the Academy.*

Flora Batava. No. 167. 4to.—*From the King of Holland.*

Guide to Northern Archæology, by the Royal Society of Northern Antiquaries of Copenhagen. Edited by the Right Hon. the Earl of Ellesmere. 8vo.—*From the Editor.*

Papers on Railway and Electric Communications, &c., &c. By Walter White. 12mo.—*From the Author.*

Rules and Regulations, and List of Members, of the Athenæum. 12mo.—*From the Athenæum.*

Monday, 15*th March* 1852.

Right Reverend BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. On the Analysis of some Scottish Minerals. By Dr A. J. Scott, H.E.I.C.S.

In this paper, the author detailed the analysis of some minerals which were placed at his disposal through the kindness of Dr Anderson, in whose laboratory they were examined by him.

Pectolite.—The first of the series was a mineral found at Storr, in the Island of Skye. It bears a great resemblance to dysclasite

in its external characters, but differs in appearance from that mineral, in possessing a much higher lustre. Its quantitative analysis gave the following results.

Silicic acid, . .	52·007
Alumina, . . .	1·820
Lime, . . .	32·854
Magnesia, . .	6·396
Soda, . . .	7·670
Water, . . .	5·058
	99·805

agreeing with the formula,

$$Na\,O,\ Si\,O_3 + (4\ Ca\,O,\ 3\ Si\,O_3) + 2\ HO,$$

the calculation being,

Silicic acid,	4 atoms,	181·2	—	52·6
Lime,	4 ...	112·0	—	32·4
Soda,	1 ...	31·3	—	9·1
Water,	2 ...	18·		
		342·5		100

which approximates much more closely to the experimental results, than the complicated formula proposed by Berzelius,

$$3\ (Na\,O,\ Si\,O_3) + 4\ (3\ Ca\,O,\ 2\ Si\,O_3) + 3\ HO.$$

The occurrence of this mineral in Scotland has not been hitherto noticed.

Natrolite.—A specimen received from Mr Rose of this city, and found in a railway tunnel at Bishopstown in Renfrewshire, was found to consist of

Silicic acid, . .	47·626
Alumina, . . .	27·170
Soda, . . .	15·124
Water, . . .	9·780
	99·700

Corresponding with the well-known formula of Natrolite,

$$Na\,O,\ Si\,O_3 + Al_2\,O_3,\ Si\,O_3 + 2\ HO.$$

Laumonite.—Found at Storr in Skye, in a vein traversing trap,

and associated with stilbite. It was supposed by some to be hypostilbite, but a quantitative examination gave the following results,

Silicic acid, . .	53·048
Alumina, . . .	22·943
Lime, . . .	9·676
Water, . . .	14·639
	100·306

This analysis corresponds to that of Laumonite, but its formula given by Gerhardt is not very satisfactory,

$$3\ Ca\ O,\ 2\ Si\ O_3 + 3\ (Al_2\ O_3,\ 2\ Si\ O_3) + 12\ HO,$$

Scolezite.—A mineral found in Mull, consisting of long radiated needles, the composition of which was found to be,

Silicic acid, . .	46·214
Alumina, . . .	27·0
Lime, . . .	13·450
Water, . . .	13·780
	100·444

corresponding to the formula of scolezite,

$$Ca\ O,\ Si\ O_3 + Al_2\ O_3,\ Si\ O_3 + 3\ HO.$$

2. On a necessary Correction in the Height of the Barometer depending on the Force of the Wind. By Captain Henry James, R.E. Communicated by Professor Piazzi Smyth.

During the frequent violent gales of last autumn, the author had remarked the excessive fluctuation of the barometer; and following up this phenomenon by means of the portable aneroid barometer, he found that not only was this fluctuation dependent on the wind and on the barometer being in a screened position; but that accompanying the fluctuation was a constant depression increasing in amount with the velocity of the air, and that this depression amounted in strong gales to a larger quantity than all the other usual corrections applied to a barometrical reading; and must be applicable to all the ordinary positions where barometers are observed, whether by sea or land.

The reason of this depression was then entered into, and the amount of numerical correction was given, as depending on the velocity of the wind, and the peculiarity of the exposure.

Some observations on the Charr (*Salmo umbla,*) relating chiefly to its Generation and Early Stage of Life. By John Davy, M.D., F.R.S. Lond. & Edin., Inspector-General of Army Hospitals.

The observations contained in this paper are given under several heads: 1*st*, on the roe and milt of the Charr; 2*dly*, on the time required for hatching the ova, and on the young fish in progress after exclusion; 3*dly*, on some agencies and circumstances supposed likely to exert an influence on both.

The principal facts which the author considers as established by his observations are the following:—

1*st*, That the time required for hatching the ova is variable, ranging from about forty to ninety days, according to the temperature of the water.

2*d*, That after exclusion the young fish can live at least sixty days without taking food, deriving the material required for its support and growth from itself, and chiefly from the store contained in its yolk.

3*d*, That under favourable circumstances it attains its perfect form in from about sixty to seventy days, when it becomes dependent for its subsistence chiefly on food which it has to seek or procure from without.

4*th*, That running water is not essential to the hatching of its ova; and in consequence of its breeding place being distinct from that of the trout, it is exposed to little risk of being lost as a species by repeated crossings with the trout.

5*th*, That salt water, even of greater saltness than sea water, is not immediately fatal to the embryo; that a partial development of the ovum may take place in brackish water; and that young fish can exist some days in such water, rendering it probable that the adult may be capable of living in a tidal stream, or even in the sea, where it is stated that the Welsh Charr has been caught.

6*th*, That the young charr can endure confinement for several days in water of small bulk, such as may be used for transporting it from place to place, especially if oxygen gas be supplied in the place of common air.

7*th*, That the young fish can bear without any immediate apparent injury, a temperature removed only a degree or two from the freezing-

point of water; and also a higher temperature, ranging from 60° to 70°; but not above 83°, a temperature which in the single instance tried was almost immediately fatal to it.

In conclusion the author briefly adverts to the application of the results obtained to the breeding and transporting of the fish, adding some remarks on the quality of water essential to its healthy condition and preservation.

Monday, 5*th April* 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. On a modification of the Process for the determination of Nitrogen in Organic Compounds. By Alexander Kemp, Esq.

Two methods are at present followed by chemists for the analysis of organic bodies containing nitrogen. In the first of these the nitrogen is directly separated from the substance, and measured in a pure state; while in the second method it is converted into ammonia, collected and weighed, its amount being calculated from the known composition of this latter substance.

In accordance with the first-named mode of proceeding, the substance is burned at a high temperature, in contact with oxide of copper, chromate of lead, or some other body capable of yielding oxygen, when the carbon of the organic substance becomes converted into carbonic acid, and its hydrogen into water, while all the nitrogen is given off in a free state. Two methods may now be adopted for ascertaining its quantity. In that recommended by M. Dumas, the evolved gases are collected in a series of graduated glass tubes, previously filled with mercury, and containing some potash ley in the upper part, which serves to absorb the carbonic acid, leaving the nitrogen, which may then be measured, and its weight calculated from its known volume and density, due allowance being made for the temperature, pressure, and the presence of aqueous vapour.

According to Liebig, the same object may be more easily and rapidly attained, by comparing the volume of the carbonic acid gas produced with that of the nitrogen given out in the operation. This

method, however, is only applicable when the amount of carbon contained in the substance is known, and would not apply to those analysis in which the nitrogen alone required to be determined. Having, as in the previously described operation, collected the mixed gases in graduated tubes, their united volume is read off and noted. After this has been done, caustic potash ley is introduced to absorb the carbonic acid. The residual gas, which is nitrogen, is then measured, and the proportion between the volumes of the two gases is at once ascertained. Now, as each atom of carbon produces one of carbonic acid, occupying the same space as an atom of nitrogen, the proportion between the number of atoms and the volumes of the two gases will be the same; and as the number of atoms of carbon is known, that of the nitrogen can be very easily calculated. The principal advantage of Baron Liebeg's method consists in this, that it is not requisite to make corrections for temperature, pressure, or watery vapour contained in the gases, as they are both subjected to the same influences in these respects.

Either of these methods will, in careful and experienced hands, yield very accurate results; but the time required, as well as the necessity of using a somewhat complicated apparatus, renders their application to common analyses almost impracticable.

A much more easily and quickly performed mode of operating was proposed a few years ago by Varrentrapp and Will. These chemists ascertained, by a series of very carefully-conducted experiments, that all organic bodies containing nitrogen, unless in the form of nitric acid, when heated in contact with a mixture of the hydrates of lime and soda, give off that nitrogen in the form of ammonia; and this being collected in a solution of hydrochloric acid, is converted into the double chloride of platinum and ammonium by the addition of bichloride of platinum; and this latter substance being carefully washed, dried, and weighed, gives, by a simple calculation, the amount of nitrogen in the analysed substance.

The method of Varrentrapp and Will, just mentioned, has the great advantage of being much more easily performed than either of the two previously referred to, and at the same time a much less complex form of apparatus may be used in the operation; nevertheless, from the necessity ef performing several operations before finally weighing the ammonio-chloride of platinum, several hours must always elapse before the result can be obtained.

An improvement on this process was suggested by M. Peligot, who conveys the evolved ammonia into a quantity of sulphuric acid of known strength, and then ascertains how much of it has been neutralised, by saturating it after the operation with an alkali, a solution of lime and sugar being used for this purpose; or, as Mr Mitchell since then proposed, caustic soda solution may be substituted for the lime with advantage, as it is not apt to change by being kept, either from spontaneous decomposition, or the absorption of carbonic acid, which indeed would not alter its neutralising power, nor affect the delicacy of the operation, unless it took place to a very great extent. This last-named method has the very great advantage of being quickly performed, so that as many as six or eight analyses can be easily made in the time required for one, according to the method of Varrentrapp and Will. The only difficulty lies in the preparation of the solution of sulphuric acid, which must be done by guess, and the proportion then ascertained by a baryta analysis, which is not a very easy operation, from the finely-divided sulphate of baryta passing readily through the filter.

From these circumstances I was induced to try if the sulphuric acid could not be replaced by some substance easily obtainable, of definite compositions, in the solid form, not hygroscopic, and of which the quantity could be easily determined by weighing, without being liable to those sources of error which apply to sulphuric and most other acids. The substance I have found to fulfil these conditions is the anhydrous bisulphate of potash, a salt described by Jacquelain in the *Annales de Chimie et de Physique* for 1839, but the existence of which seems to be doubted by many chemists. Into this point I shall not at present enter particularly, as I have not yet completed some observations upon this subject with which I have lately been engaged; but this has been ascertained, that if more than two equivalents of sulphuric acid be added to any salt of potash containing a volatile acid, and the mixture be exposed to heat at a certain temperature, hydrated bisulphate of potash is formed; and if the temperature be now raised to incipient redness, in the dark, vapours escape, and the anhydrous bisulphate, of perfectly definite composition, remains, which suffers no farther alteration, even when the heat is continued for so long a period as three hours—that is, if it be not carried beyond incipient redness in the dark.

In order to ascertain this latter point, I have had eight specimens

prepared and analysed in several different ways. 1st, 10 grains, precipitated by nitrate of baryta, gave 18·31 grains of sulphate of baryta, theory requires 18·33 grains; while, for the hydrated bisulphate, 17·12 grains would be the quantity. 2d, 12·72 grains in a second experiment gave 23·24 baryta salt, theory 23·32.

2d, 12·72 grains of the salt were carefully introduced into a hard glass tube, and an excess of freshly-ignited oxide of lead added, but so as not to come in contact with the salt, the tube with its contents was then carefully weighed, and heated to redness so as to fuse both substances, but no loss of weight could be detected; the hydrated salt would have lost about 0·8 grains.

3d, 12·72 grains of the salt were dissolved in hot water, and slightly coloured with litmus; to this was added a solution of 5·32 grains of recently-ignited carbonate of soda in a measured quantity of water; the whole of this, being the calculated quantity, was required to restore the blue colour to the hot solution coloured by the litmus.

4th, The whole of the eight specimens were tested as to their neutralising powers by means of the same solution of caustic soda, and found to agree; there can therefore be little doubt that the anhydrous bisulphate of potash can be easily got, and of definite composition.

Having thus endeavoured to shew that the anhydrous bisulphate of potash can be obtained of definite neutralising power, little need be said with regard to its application, as it is intended merely as a substitute for the sulphuric acid used in Peligot's process, and that entirely on account of the ease with which its quantity may be determined by weighing alone, without the necessity of having recourse to any mode of analysis, as is indispensable when any acid solution is made use of. One other advantage may be mentioned—the salt is neither deliquescent nor hygroscopic, for when 10 grains in fine powder were exposed in the laboratory during the night in an open watch-glass, they had not gained ·001 grain by the morning.

In employing the salt in an analysis, any convenient quantity is weighed out and dissolved in warm water in a beaker-glass, and slightly coloured with litmus; a part of this solution is then introduced into the bulb-tube, and made use of in the analysis; afterwards it is returned to the beaker-glass, and neutralised with solution of caustic soda; the difference between the quantity of soda required,

and what would have been required before the combustion, gives us one of the elements for calculating the analysis.

In order to neutralise the acid reaction of one equivalent of the bisulphate, one equivalent of ammonia will be required; therefore 127·2 grains of the salt will correspond to 17 grains of ammonia, or to 14 grains of nitrogen.

I may add, that the high atomic weight of the bisulphate (127·2) tends to diminish any errors from inaccurate weighing, or the presence of impurities.

5th, Two comparative analyses of pure uric acid were made at the same time; 6 grains gave, by Varrentrapp and Will's method, 31·90 of the platinum salt, = 33·4 per cent. of nitrogen; theory gives 33·33; 5 grains uric acid gave, by the bisulphate process, 33·376 per cent. of nitrogen; theory, 33·333.

Many other analyses have been made by this process in the University laboratory, and with the most satisfactory results, approaching in general more closely to the calculated quantities than by the method with bichloride of platinum.

It is obvious that the bisulphate of potash may be employed with advantage as a substitute for sulphuric acid in common alkalimetry, since it is easier to prepare a solution of the anhydrous bisulphate of any given strength than to obtain a standard dilute sulphuric acid.

2. An account of some Experiments on the Diet of Prisoners. By Professor Christison.

From careful experiments made, under direction of the Board of Directors of Prisons in Scotland, on 1624 prisoners confined in eight of the principal prisons, for periods not exceeding sixty days; and from an analysis of numerous observations on their weight and general health, the author arrives at the following conclusions:—

1. For the average of people whose occupation involves moderate muscular effort and no great exercise, a simple, well-selected sort of food, supplying seventeen ounces of daily real nutriment, of which four ounces are nitrogenous principles, constitutes a sufficient diet for maintaining health, strength, weight, and general condition; but less is not sufficient.

2. The proportion of nitrogenous nutriment in such a diet cannot

be very sensibly reduced below four ounces a-day without risk of injury.

3. This amount of nutriment, though in general adequate for the average in the supposed circumstances, is not always so.

4. It is probably inadequate for those who have been accustomed to a vigorous occupation in the open air, and a liberal dietary, even when their employment is changed for one involving no great muscular effort or exercise.

5. It is inadequate for a fair proportion of persons considerably exceeding the average in bulk.

6. It is inadequate for a considerable proportion of growing lads between sixteen and twenty.

7. It is more generally adequate for females than for males.

8. It is rendered occasionally inadequate by other causes not distinctly indicated by the observations in the Scottish prisons, but certainly independent of any increase in habitual muscular exertion.

9. Hence the economical regulation of the diet of bodies of men must always be a matter of great difficulty; and if deviations from the standard dietary be not allowed with a liberal discretion, injury will be apt to ensue. And here it should be added from other observations, that suspicion may be lulled by no very perceptible injury except loss of weight occurring in ordinary seasons; while, nevertheless, manifest injury will arise in periods of epidemic disease.

10. The prison dietary in Scotland has been very successfully adjusted by long experience in most of the prisons, so far as regards the class of prisoners who formed the subject of the preceding observations and experiments,—viz., those imprisoned for terms not exceeding two months. But in that dietary treacle-water cannot be substituted for milk without a reduction of flesh, the forerunner of probable ill health, unless some compensation be made in other articles of food. It has, in fact, been disallowed by the Board since these experiments were made.

11. In adjusting dietaries, and in all practical inquiries into the subject, reliance ought never to be put on practical observation alone; but scientific analysis should be likewise brought into requisition. Numberless errors committed by merely practical men might easily be quoted, which could scarcely have escaped notice had they united scientific knowledge to practical skill.

3. Researches on some of the Crystalline Constituents of Opium. By Dr Thomas Anderson.

The author commenced his paper by referring to the numerous researches on opium which had already appeared, and stated that notwithstanding their number and extent, our information on the properties and composition of its various bases and indifferent constituents was still extremely imperfect. He had therefore submitted some of them to a renewed examination, employing as the source from which they were obtained the mother liquor of the manufacturers of muriate of morphia. By treatment of this liquor in a manner detailed in full in the paper, he obtained from it a large quantity of narcotine, and a certain proportion of thebaine and narceine.

Narceine was obtained in the form of extremely delicate needles, which mat together into a silky mass. It is soluble in water and alcohol, but not in ether. Potash and ammonia in moderately dilute solutions dissolve it more readily than water, but the addition of a large quantity of caustic potash causes its precipitation in shining scales. Concentrated sulphuric acid dissolves it in the cold, with an intense red colour, passing into green on the application of heat. Hydrochloric acid dissolves it entirely, but without producing the blue colour which, according to Pelletier, is characteristic of narceine. Narceine, though incapable of restoring the colour of reddened litmus, possesses feebly basic properties, and forms salts with the strong acids. Its analysis gave results corresponding with the formula $C_{46} H_{29} NO_{18}$, which was confirmed by the analysis of its platinum salt. The hydrochlorate, platinochloride, sulphate, and nitrate, are also described.

Thebaine crystallises in fine silvery plates. It is insoluble in water, but very soluble in alcohol and ether. It forms salts which cannot be obtained in crystals from their aqueous solution. It is insoluble in potash and ammonia. Strong sulphuric acid reacts upon it, and produces an intense blood-red colour even when entirely free from nitric acid. Sulphuric acid of specific gravity 1·300 dissolves it in the cold, but on heating a resinous semisolid mass is thrown down, which slowly dissolves in boiling water, and deposits on cooling a rather sparingly soluble salt in microscopic needles, which appears to be a product of decomposition.

Analysis shewed the composition of thebaine to be represented by the formula $C_{38} H_{21} NO_6$.

The Hydrochlorate of Thebaine is obtained by adding to thebaine an alcoholic solution of hydrochloric acid until the base is dissolved, excess being carefully avoided. On standing, the salt is deposited in fine rhomboidal crystals, often of considerable size. Their formula, when dried at 212°, is $C_{38} H_{21} NO_6 HCl + 2HO$.

Platinochloride of Thebaine is obtained as a yellow powder, slightly soluble in boiling water. The formula is $C_{38} H_{21} NO_6 HCl PtCl_2 + 2HO$.

The author then proceeds to detail the phenomena attendant on the action of nitric acid on *narcotine*. When concentrated nitric acid is added to narcotine, very violent action takes place, and a fluid is obtained which, on evaporation, yields an amorphous orange residue. When the acid is employed in a dilute state, and at a temperature not exceeding 120°, the narcotine slowly dissolves, and when the solution is complete, the fluid deposits a small quantity of a substance to which the author gives the name of *teropiammon*, and which is represented by the formula $C_{60} H_{29} NO_{26}$, and is derived from three equivalents of opianic acid and one of ammonia, minus the elements of four equivalents of water. The fluid which has deposited this substance contains *cotarnine*, which is precipitated by potash; and the potash solution contains, according to the extent to which the oxidation has gone, either opianic or hemipinic acid, or a third substance, to which the author gives the name of *opianyl*, and which is represented by the formula $C_{20} H_{10} O_8$. The author describes the properties of this substance and its hydrate. He then details the properties of certain compounds of opianic and hemipinic aicds, from which he comes to the conclusion that the latter is a bibasic acid, and is correctly represented by the formula $C_{20} H_{10} O_{12}$. An acid potash salt, and an acid ether, hemipinovinic acid, are described.

The cotarnine, which is formed by the action of dilute nitric acid on narcotine, when treated with stronger acid, undergoes a further decomposition, and yields a variety of products, which are obviously the result of several different decompositions occurring simultaneously. The most abundant product of this action is a crystallisable acid possessing all the characters of Wöhler's apophyllic acid. It is best obtained by treating cotarnine with moderately strong

nitric acid, and then adding alcohol and ether, which throws down the new acid in small crystals. It is soluble in water, and by evaporation yields fine crystals. In alcohol and ether it is quite insoluble. It fuses at 401°, and dissolves readily in potash and soda. The composition was found to be represented by the formula $C_{16}\ H_7\ NO_8$, differing from that of anthranilic acid by the elements of two equivalents of carbonic acid.

Its salts are all highly soluble in water, and are with difficulty obtained in the crystalline form. Its silver salt can only be prepared by digesting the acid with oxide of silver, as when a neutral apophyllate is added to nitrate of silver a precipitate of a double nitrate and apophyllate of silver is obtained, which explodes when heated.

When the solution containing alcohol and ether, from which the apophyllic acid has been thrown down, is evaporated, and then distilled with potash, a volatile base is obtained, which possesses the composition and properties of methylamine, and under certain circumstances ethylamine also appears to be formed.

The following is a tabular statement of the substances examined in the paper.

Narceine, . . .	$C_{46}\ H_{29}\ NO_{18}$
Hydrochlorate of narceine, .	$C_{46}\ H_{29}\ NO_{18}\ HCl$
Platinochloride of narceine,	$C_{46}\ H_{29}\ NO_{18}\ HCl\ Pt\ Cl_2$
Robiquet's narceine, .	$C_{32}\ H_{19}\ NO_{10}$ (?)
Thebaine, . .	$C_{38}\ H_{21}\ NO_6$
Hydrochloride of thebaine,	$C_{38}\ H_{21}\ NO_6\ HCl + 2\ HO$
Platinochloride of thebaine,	$C_{38}\ H_{21}\ NO_6\ HCl\ Pt\ Cl_2 + 2\ HO$
Teropiammon, . .	$C_{60}\ H_{29}\ NO_{26}$
Opianyl, . . .	$C_{20}\ H_{10}\ O_{10}$
Hydrate of opianyl, .	$C_{20}\ H_{10}\ O_8 + HO$
Opianic acid, . .	$C_{20}\ H_{10}\ O_{10}$
Opianic ether, . .	$C_4\ H_5\ O,\ C_{20}\ H_9\ O_9$
Hemipinic acid, . .	$C_{20}\ H_{10}\ O_{12}$
Acid hemipinate of potass, .	$KO\ HO\ C_{20}\ H_8\ O_{10}$
Hemipinate of silver, .	$2\ Ag\ O\ C_{20}\ H_8\ O_{10}$
Hemipinovinic acid, .	$HO\ C_4\ H_5\ O\ C_{20}\ H\ \ O_{10}$
Apophyllic acid, .	$C_{16}\ H_7\ NO_8$
Apophyllate of silver, .	$Ag\ O\ C_1\ \ H_6\ N\ O_7$
Methylamine, . .	$C_2\ H_5\ N$
Ethylamine, . .	$C_4\ H_7\ N$

4. On the Red Prominences seen during Total Eclipses of the Sun. Part I. By William Swan, F.R.S.E.

The object of this communication is to discuss the evidence afforded by various observations of the eclipse which occurred on the 28th July 1851, as to the nature of the rose-coloured prominences which are seen round the moon during the total phase of solar eclipses.

In order to render the inquiry into the nature of the red prominences as complete as possible, the author has not confined himself to the consideration of such hypotheses only as have been formally stated regarding them; but has also included in his examination such other views as he thought might probably be entertained regarding those remarkable objects.

The observations of the eclipse discussed by the author are chiefly contained in the Royal Astronomical Society's Notice for January 1852, and the following are the conclusions to which he has been led by the examination of those observations:—

1. The red prominences were not caused by the telescopes used in viewing the eclipse; for they were seen by the naked eye.

2. The red prominences cannot be regarded as optical phenomena, produced either by unequally heated air, as supposed by M. Faye, or by the action of the moon's limb on the sun's light; for these hypotheses are inconsistent both with the permanency of form displayed by the prominences, and with the general similarity of their appearance, as seen from stations differently situated with reference to the line of central eclipse.

3. While the optical hypotheses thus labour under difficulties peculiar to themselves, the objections to the opinion that the red prominences are *material* objects existing in the sun, founded on the discrepancies in the observations, as to their number, forms, and positions, are found to apply with equal force to the optical hypotheses.

4. Little care seems, in some instances, to have been taken in ascertaining the positions of the red prominences, and accordingly great discrepancies occur among the observations; while in certain cases they agreed remarkably well. Mr Dawes and the author, who both used means for obtaining an accurate estimation of angles of

position, differ by less than a degree in the place they assign to the most conspicuous prominence seen at the late eclipse, and they also assign to it almost exactly the same form. This, and other coincidences between observations made at distant stations, are strongly in favour of the idea that the prominences are material objects.

5. The observed differences in the numbers and positions of the red prominences, as seen from stations differently situated in the moon's shadow, are, upon the whole, accordant with the effects which parallax would produce, if the prominences actually existed in the sun.

6. The hypothesis that the prominences exist in the sun seems to afford the only explanation of the fact, that the moon gradually occulted them on the side towards which it moved, and exposed them on the other, while at the same time the outlines of those portions of the prominences which continued visible, as well as their relative positions, remained unaltered.

7. On these grounds it is inferred that the red prominences are *material* objects existing on the sun.

The following Gentleman was duly elected an Ordinary Fellow:—

James William Grant, Esq. of Elchies.

The following Donations to the Library were announced:—

The Assurance Magazine. No. 5. 8vo.—*From the Institute of Actuaries.*

Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou. Tome IX. 4to.

Bulletin de la Société Impériale des Naturalistes de Moscou. 1851. No. 2. 8vo.—*From the Society.*

Monday, 19th April 1852.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On the Red Prominences seen during Total Eclipses of the Sun. Part II. By William Swan, F.R.S.E.

In the first part of this paper, the author endeavoured to shew,

from a comparison of various observations of the red prominences seen at the eclipse of the 28th July 1851, that those objects were not mere optical phenomena, but that they actually existed in the sun.

The object of the present communication is to offer some conjectures regarding the nature of the red prominences, and their possible connection with other solar phenomena.

The comparatively faint light reflected by the prominences, their overhanging forms, and the appearance at the late eclipse, of a prominence completely detached from the moon's limb, all conspire to prove that they are cloudy masses floating in the sun's atmosphere; while the existence of a long range of red prominences, which, at certain stations, was seen extending over nearly a third part of the moon's limb, together with their tolerably uniform distribution all round the rest of the moon's edge, prove that the matter composing them is very copiously diffused through the sun's atmosphere.

To account for the existence of the red prominences, the author supposes that the sun's luminous atmosphere is surrounded by an *envelope of cloudy matter*, capable of absorbing part of his light, and reflecting chiefly the red rays of the spectrum—a conjecture which is founded both on the observed general distribution of the red prominences, and on the appearance of a band of red light just before the end of the total phase of the eclipse, which was seen extending round the moon's limb, about the point where the sun emerged. The serrated outline of the long range of prominences indicates that the surface of the stratum of cloud is exceedingly uneven, and its higher portions seen beyond the edge of the moon, may constitute red prominences. It is also however supposed, that just as the spots on the sun have been conceived to arise from upward currents in the solar atmosphere, removing portions of its luminous stratum; the same, or similar currents, may penetrate the superincumbent stratum of cloud, carry upwards the edges of the aperture it has formed, and detach masses of cloud, so as to form higher and more remarkable prominences, like the more striking objects of that kind which were seen at the late eclipse.

The author conceives that this view regarding the nature of the red prominences, may also serve to explain other solar phenomena.

1. The darkness of the sun's edge, compared with his centre, is generally attributed to the absorbent action of the solar atmosphere on light; but unless the thickness of the absorbent atmosphere be

small, when compared with the sun's diameter, the difference of its action on the central and lateral rays would be insensible. On the other hand, the wide extension of the corona indicates that the sun's atmosphere is of great thickness compared with his diameter; and there is, therefore, difficulty in supposing the darkness of the sun's edges to arise from the *general* absorption of light by his atmosphere. That phenomenon, however, is easily explained by supposing it to arise from the absorbent action of a comparatively thin stratum of cloud surrounding the sun.

2. The faculæ are generally understood to be ridges in the sun's luminous atmosphere; but the author supposes them to be apertures in the envelope of cloud, through which his rays pass more freely than elsewhere. The greater distinctness of the faculæ when seen near the sun's limb, is explained by the light shining through the apertures being there contrasted with light which has suffered absorption by passing obliquely through the envelope of cloud; while towards the centre the contrast is not so great, as the light passes nearly perpendicularly through the envelope, and is therefore less absorbed.

3. The supposition that the larger prominences are situated on the edges of apertures in the envelope of cloud is consistent with the increased brightness of the corona in their neighbourhood, which was observed at the late eclipse.

4. The existence of an envelope of cloud surrounding the sun, capable of absorbing light, but penetrated by apertures, and therefore transmitting light more freely at certain places than at others, may serve to explain the great want of uniformity in the brightness of the corona, and the brilliant beams of light which occur in it at certain points.

The hypothesis that an envelope of cloud surrounds the sun, thus refers to one physical cause, a variety of solar phenomena, namely, the darkness of the sun's limb compared with his centre, the existence of faculæ on his disc, the discontinuous illumination of the corona, the existence of the red prominences, and the occasional increased brightness of the corona in their neighbourhood.

The idea that a cloudy envelope surrounds the sun, occurred to the author immediately after witnessing the eclipse of 28th July 1851, when he reflected on the striking want of uniformity he had observed in the illumination of the corona.

That phenomenon strongly impressed on him the conviction, that something existed at the surface of the sun which intercepted his light, more at certain points than at others; and he conceived that the matter composing the red prominences, might be the absorbent medium which produced that effect.

2. On a Universal Tendency in Nature to the Dissipation of Mechanical Energy. By Professor William Thomson.

The object of the present communication is to call attention to the remarkable consequences which follow from Carnot's proposition, established as it is on a new foundation, in the dynamical theory of heat; that there is an absolute waste of mechanical energy available to man, when heat is allowed to pass from one body to another at a lower temperature, by any means not fulfilling his criterion of a "perfect thermo-dynamic engine." As it is most certain that Creative Power alone can either call into existence or annihilate mechanical energy, the "waste" referred to cannot be annihilation, but must be some transformation of energy.* To explain the nature of this transformation, it is convenient, in the first place, to divide *stores* of mechanical energy into two classes—*statical* and *dynamical*. A quantity of weights at a height, ready to descend and do work when wanted, an electrified body, a quantity of fuel, contain stores of mechanical energy of the statical kind. Masses of matter in motion, a volume of space through which undulations of light or radiant heat are passing, a body having thermal motions among its particles (that is, not infinitely cold), contain stores of mechanical energy of the dynamical kind.

The following propositions are laid down regarding the *dissipation* of mechanical energy from a given store, and the *restoration* of it to its primitive condition. They are necessary consequences of the axiom, "*It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects.*" (*Dynam. Th. of Heat*, § 12.)

I. When heat is created by a reversible process, (so that the mechanical energy thus spent may be *restored* to its primitive con-

* See the Author's previous paper on the Dynamical Theory of Heat, § 22.

dition,) there is also a transference from a cold body to a hot body of a quantity of heat bearing to the quantity created a definite proportion depending on the temperatures of the two bodies.

II. When heat is created by any unreversible process (such as friction,) there is a *dissipation* of mechanical energy, and a full *restoration* of it to its primitive condition is impossible.

III. When heat is diffused by *conduction*, there is a *dissipation* of mechanical energy, and perfect *restoration* is impossible.

IV. When radiant heat or light is absorbed, otherwise than in vegetation, or in chemical action, there is a *dissipation* of mechanical energy, and perfect *restoration* is impossible.

In connection with the second proposition, the question, *How far is the loss of power experienced by steam in rushing through narrow steam-pipes compensated, as regards the economy of the engine, by the heat* (containing an exact equivalent of mechanical energy) *created by the friction?*—is considered; and the following conclusion is arrived at:—

Let S denote the temperature of the steam, (which is nearly the same in the boiler and steam-pipe, and in the cylinder till the expansion within it commences); T the temperature of the condenser; μ the value of Carnot's function for any temperature, t; and R the value of

$$\epsilon^{-\frac{1}{J}\int_{T}^{S}\mu\, dt}.$$

Then $(1-R)w$ expresses the greatest amount of mechanical effect that can be economised, in the circumstances, from a quantity $\frac{1}{J}w$ of heat produced by the expenditure of a quantity, w, of work in friction, whether of the steam in the pipes and entrance-ports, or of any solids or fluids in motion in any part of the engine; and the remainder, R w, is absolutely and irrecoverably wasted, unless some use is made of the heat discharged from the condenser. The value of $1-R$ has been shewn to be not more than about one-fourth for the best steam-engines, and we may infer that in them at least three-fourths of the work spent in any kind of friction is utterly wasted.

In connection with the third proposition, the quantity of work that could be got by equalising the temperature of all parts of a solid body possessing initially a given non-uniform distribution of heat, if this could be done by means of perfect thermo-dynamic engines

without any conduction of heat, is investigated. If t be the initial temperature (estimated according to any arbitrary system) at any point $x\,y\,z$ of the solid, T the final uniform temperature, and c the thermal capacity of unity of volume of the solid, the required mechanical effect is of course equal to

$$J \iiint c\,(t-T)\,dx\,dy\,dz,$$

being simply the mechanical equivalent of the amount of heat put out of existence. Hence the problem becomes reduced to that of the determination of T. The following solution is obtained,—

$$T = \frac{\iiint \epsilon^{-\frac{1}{J}\int_0^t \mu dt}\, ct\,dx\,dy\,dz}{\iiint \epsilon^{-\frac{1}{J}\int_0^t \mu dt}\, c\,dx\,dy\,dz}.$$

If the system of thermometry adopted* be such that $\mu = \frac{J}{t+\alpha}$, that is, if we agree to call $\frac{J}{\mu} - \alpha$ the *temperature* of a body, for which μ is the *value of Carnot's function*, (α and J being constants,) the preceding expression becomes

$$T = \frac{\iiint c\,dx\,dy\,dz}{\iiint \frac{c}{t+\alpha}\,dx\,dy\,dz} - \alpha.$$

The following general conclusions are drawn from the propositions stated above, and known facts with reference to the mechanics of animal and vegetable bodies :—

1. There is at present in the material world a universal tendency to the dissipation of mechanical energy.

2. Any *restoration* of mechanical energy, without more than an equivalent of dissipation, is impossible in inanimate material processes, and is probably never effected by means of organised matter,

---

* According to "Mayer's hypothesis," this system coincides with that in which equal differences of temperature are defined as those with which the same mass of air under constant pressure has equal differences of volume, provided J be the mechanical equivalent of the thermal unit and $\frac{1}{\alpha}$ the coefficient of expansion of air.—See the author's previous paper "On the Heat produced by the Compression of a Gas," &c., § 5.

either endowed with vegetable life, or subjected to the will of an animated creature.

3. Within a finite period of time past the earth must have been, and within a finite period of time to come the earth must again be, unfit for the habitation of man as at present constituted, unless operations have been, or are to be performed, which are impossible under the laws to which the known operations going on at present in the material world are subject.

3. On Rifle Cannon. By Captain Davidson, Bombay Army. Communicated by Professor C. Piazzi Smyth.

This paper was written in India as far back as 1839, but many of its suggestions were still untried, and present circumstances seem to urge their importance.

The recent improvements in the hand-rifle have so greatly increased the practical range of that instrument, as to have passed and left far behind, in point of range and precision, the heavy field pieces which heretofore have done accurate execution at distances impracticable to small arms. The large guns therefore imperatively require to undergo the same alteration which, by converting the musket into a rifle, has so greatly increased the directness and accuracy of the flight of its ball.

Rifling has already been tried on cannon, but not with success; and Captain Davidson's paper merely professed to give an improved method of applying the principle. This he effected by inserting into the sides of the shot or shell, ribs of wood, to fit into the rifle grooves of the bore. In this way he considered that the necessary rotation would be given to the ball, without the usual error of tearing and destroying the figure of the interior of the gun; the soft wooden ribs, and not the hard cast-iron of the Captain's projectiles, alone coming into contact with the bore,

To this method of rifles he proposed also to join the conical form for the projectile, fired with the *small end* first, and to make the shells self-exploding, by a percussion cap on the extremity.

Having entered somewhat into the principle and history of rifle pieces, the Captain gives the concluding portion of the pamphlet on the same subject by Mr Robins, the Newton of gunnery, as valuable in itself, and strangely unattended to through more than half a century.

"I shall therefore close this paper (Mr Robins' words) with predicting, that whatever state shall thoroughly comprehend the nature and advantages of rifled barrel pieces, and, having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them; they will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of fire-arms."

4. On two New Processes for the detection of Fluorine when accompanied by Silica, and on the presence of Fluorine in Granite, Trap, and other Igneous Rocks, and in the Ashes of Recent and Fossil Plants. By Dr George Wilson.

The author, after alluding to his previous communications to the Society in reference to fluorine, stated that he had always attributed the slight indications of the presence of this element in plants, which his own investigations and those of others had yielded, to the amount of silica which was contained in vegetable ashes. The presence of silica, which throws special difficulties in the way of detecting fluorine, had also prevented him from seeking for it in trap rocks and other mineral masses. Recently, however, he had put in practice two processes, which were applicable to all bodies containing silica and a metallic fluoride, which are decomposed by boiling oil of vitriol. When this acid is heated along with a silicated fluoride, it occasions an evolution of the fluorine in combination with silicon, as the well-known gaseous fluoride of silicon ($Si\ F_3$). In the first process, this gas is conducted into a solution of caustic potash, in which it occasions a precipitate of the fluoride of silicon and potassium ($2\ Si\ F_3 + 3\ K\ F$). This precipitate is heated in a metallic crucible with potassium, so as to separate the silicon, and convert the double fluoride into fluoride of potassium. When moistened with oil of vitriol, it evolves hydrofluoric acid, the escape of which is easily recognised by its etching glass. This process gave good results, but was tedious, and sometimes unsuccessful. It was accordingly abandoned for the

second process, in which ammonia is substituted for potass, and the use of potassium is dispensed with.

The following are the steps of the ammonia process. The silicated fluoride, such as trap-rock or the ashes of straw, is heated with oil of vitriol, and the fluoride of silicon which is given off is conducted by a bent tube into an aqueous solution of ammonia, with which it forms the fluoride of silicon and ammonium ($2\ Si\ F_3$ + $3\ NH_4\ F$). When this is evaporated to perfect dryness, the silicon becomes insoluble silica, from which water dissolves out the pure fluoride of ammonium. This ammonio-fluoride is dried up in a platina crucible, and after moistening the residue with sulphuric acid, a piece of waxed glass, with lines traced through the wax down to the glass, is laid as a cover on the crucible, so as to permit the hydrofluoric acid evolved to etch the lines.

This process has been tried with Peterhead and Aberdeen granite, with basalt from Arthur's Seat, greenstone from Corstorphine Hill, and clinkstone from Blackford Hill, all in the neighbourhood of Edinburgh. It has also been tried with the ashes of barley-straw, of hay, of coal, and of charcoal; and in addition, with a fossil bone containing much carbonate of lime; and with the deposit from the boiler of an ocean steamer. To the bone, and to the boiler deposit, pounded glass was added. Most of the specimens obtained in this way were shewn to the Society. These, the author stated, were not selected successful ones, but represented the earliest trials. Where the rocks under examination had been weathered, or the substances, such as plant-ashes, contained salts of volatile acids, as chlorides and carbonates, they were treated, first, with oil of vitriol, *in the cold*, so as to evolve hydrochloric acid and carbonic acid. On afterwards raising the liquid to the boiling point, in a flask with a bent tube, a gas was given off, if fluorine were present, which deposited gelatinous silica when passed through water, and produced with it a solution which gave a gelatinous precipitate with potash. The whole of the fluoride of silicon is given off as soon as the oil of vitriol has reached its boiling point. The author is at present engaged in applying this process to a variety of substances, and in ascertaining its applicability to the quantitative determination of fluorine.

In conclusion, it was noticed that the discovery of fluorine in trap and granite, threw much light on the production of minerals, such as fluor spar and crystallised silica, which are found in these rocks;

and that the detection of the element under notice in marked quantity in plants, prepares us for the recognition of fluorine as a constant ingredient of the tissues of animals, who receive it both in their solid food, and in the water which they drank. The author, however, forbore to enlarge, upon the application of his discovery of the wide distribution of fluorine, till he analysed an additional number of substances for it.

The following Donations to the Library were announced :—

The Nature and Treatment of Diseases of the Heart. By James Wardrop, M.D. 8vo.—*From the Author.*

Twentieth Report of the Scarborough Philosophical Society.—8vo.—*From the Society.*

Minutes of Proceedings of the Institution of Civil Engineers. 1849–50—1850–51. 8vo.

List of Members of Ditto.—*From the Institution.*

Assurance Magazine. No. 7. 8vo.

Constitution and Laws of the Institute of Actuaries of Great Britain and Ireland. 8vo.—*From the Institute.*

Transactions of the Cambridge Philosophical Society. Vol. IX. Part 2. 8vo.—*From the Society.*

The American Journal of Science and Arts. Second Series. No. 38. 8vo.—*From the Editors.*

Flora Batava. Aflevering 168. 4to. — *From the King of Holland.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1852–53. No. 43.

Seventieth Session.

Monday, 6th December 1852.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read :—

1. On a supposed Meteoric Stone, alleged to have fallen in Hampshire in September 1852. By Dr George Wilson.

The object of this communication was to exhibit to the Society a mineral which had been publicly described as a meteoric stone, picked up by a witness of its fall. The author had been induced, by the published account of the alleged fall of the stone, to make inquiry concerning it, and had ascertained that no one had witnessed its descent; and that the only evidence in favour of its being a meteorite was the fact of its having been noticed for the first time in a garden-path, the morning after a thunder-storm.

The mineral had not the characters of any known meteorite, being simply a large nodule of iron pyrites or bisulphuret of iron, oxidised at the surface into brown hæmatite.

The author drew attention to the fact that such nodules were popularly known, in the chalk districts of England, as "thunderbolts,"

a title which seemed to him a recognition of the fall of aerolites, and especially of meteoric iron, which, after oxidation, would closely resemble the oxidised pyrites.

In Scotland and the north of Europe, the term "thunderbolt" had long been applied to ancient flint arrow-heads and stone celts; and throughout the island a well-known fossil, the *belemnite*, had received the same appellation. The author did not regard those bodies as named primarily in reference to meteorites, but rather as representing the popular idea of lightning as something shot like an arrow from a thunder-cloud.

The paper concluded with the suggestion that the art of working iron had been learned by primitive nations from the manipulation of metallic meteorites, the rusting of which further taught them that brown and red hæmatite contain iron.

2. On the Glacial Phenomena of Scotland, and parts of England. By Robert Chambers, Esq.

This paper commenced with an account of *Ancient Moraines connected with Corries or Small Valleys*. Sir Charles Lyell had described one as forming the retaining dam of Loch Brandy, on the eastern skirts of the Grampians, and Mr Charles Maclaren had discovered another in Glenmessan, near the Firth of Clyde. The author of the paper described a few others which he had discovered. At Corryhashtel, on the side of Ben-Blaven, in the Isle of Skye, there are three distinct parallel lines of blocks along the right side of the valley, which are presumed to mark the right skirt of a local glacier at three points in the history of its shrinking. In a deep rough valley at the opposite side of the mountain, there are several mounds of rough stones mingled with smaller detritus, which are presumed to have been the terminal moraines of a glacier once filling that valley. The author has likewise found detrital heaps and ridges, fully answering the character of moraines, in connection with various *corries* or short valleys in the alpine districts of Applecross in Ross-shire, and Assynt in Sutherlandshire, and in some of these instances he has found the rocks in the valleys presenting smoothed and scratched surfaces.

The next section of the paper related to *Proofs of Ancient Glaciers in limited Mountain Districts*. The author had recently as-

certained that the Lake District of Cumberland and Westmoreland bears incontestable traces of the former existence of glaciers originating in its high grounds, and passing down the valleys. In Borrowdale, in Ulleswater, in Thirlmere, in Grasmere, and Windermere, and in the vale of the Kent, rounded hummocks of rock, presenting an exposed side up the valley, and a rough side in the contrary direction, are abundantly seen. Flat surfaces of rock, finely smoothed and striated in the line of the valley, are presented at Grange in Borrowdale, at Patterdale in Ulleswater, and at Staveley in Kentdale. In many places, detrital accumulations of precisely the character of the moraines of the Alps, and of a brown colour, are found; but they have not been seen in any definite arrangement suggesting the idea of terminal or lateral moraines, excepting in one instance near the head of the Thirlmere valley, where a long mound of blocks rests on the hill-face, in the angle between the principal and a side valley,—a form exactly resembling the ancient moraine of the extended Glacier des Bois, at Tines in Chamouni. At Dunmailraise, which is a col or summit out of the range of any possible glacier of the district, there is a deep accumulation of clayey matter and blocks, which the author thinks probably of greater antiquity than the glaciers of the district, and referable to earlier phenomena of a kindred character.

The author adverted to Snowdonia, in North Wales, as an ancient glacier district, of precisely the same character as that of the Cumbrian Lakes; there being here seven radiating valleys, all containing the usual proofs of the passage of ancient glaciers. These have been described several years ago, and now Professor Ramsay discovers the remarkable fact that the northern drift, which abounds in neighbouring districts, is here only found in out-of-the-way corners, and in elevated situations.

Mountain regions so limited and definite as those of North Wales and Cumbria do not exist in Scotland; but the author has nevertheless found proofs of local systems of glaciers almost equally well defined. He points to one instance in Assynt, Sutherlandshire, where there is proof of one glacier passing along through the vale in which Loch Assynt lies, and out to sea at Storr; while another, descending from the same elevated ground at Ben-Uie and Ben-More, moved along the valley which contains the estuary of Kyle Skow.

The paper next proceeds to bring forward *Proofs of a more General Glaciation in Scotland.*

Traces of glacial action in the smoothing and furrowing of rocks, and in the deposit of the appropriate detrital accumulations and blocks, have heretofore been detected in various parts of Scotland. In the southern and eastern skirts of the Highlands, the direction indicated for the agent is southerly and easterly. In the valley of the Firth of Forth, both in the low grounds, and high up the hills on both sides, are phenomena of this kind, with an indication of direction from about WSW. Having found a few instances in the north of Argyllshire and parts of Inverness-shire, where the agent appeared to have had a direction from the east, Mr Maclaren and M. Charles Martins had become satisfied that there had been ordinary glaciers in the group of mountains between the Clyde and Lochaber, and that they had, as usual, radiated outwards. Thus it was held as possible to account for the whole phenomena which had been observed.

The author of the present paper has extended his observations to the large Highland district to the northward of the great glen, and particularly to the old red sandstone district of western Ross and Sutherland. He has there found glacially-smoothed rocks, even more abundantly than in the southern region. They occur in many valleys, generally in the line of the valleys, and also on many elevated situations, even to 2000 feet above the level of the sea. In all elevated positions, and in all open regions free of valleys, the line of the striation shews a marked tendency to observe one direction, and that between north-west and south-east. This is alike the case in Mull and in Skye, on Ben-Eay beside Loch Maree in Ross-shire, and on the mountains of Cuineag and Canisp in Sutherlandshire, in the wide-spread rocky plains of Lord Reay's country, and on the gentle undulations of Caithness. The white quartz rocks of the Assynt mountains retain the striation over wide areas and with great clearness. It is also remarkable that some of these mountains are of a narrow lengthy form, with the longitudinal axis in the same direction as the striation, while the intermediate hollows, containing the long lakes for which the district is remarkable, observe the same direction. The whole series of the old red sandstone mountains of Ross and Sutherland, extending for fifty miles, observe a horizontal stratification, so that each separate hill looks like a pile of masonry resting on a gneissic platform. Find-

ing the hills themselves, and the intermediate spaces, marked glacially, and the glacial striæ, and the lengths of the hills and intermediate hollows, all conformable in direction, the author of the paper thinks it probable that ice, not water, will yet be concluded to have been the cause of this notable example of the phenomenon of Denudation; and, consequently, of many others where its operations have not as yet been suspected.

It is in the midst of this district of old red sandstone mountains, that the author discovered the traces of local glaciers passing through the vale of Loch Assynt, and that containing the estuary of Kyle Skow. These consisted of moraines damming up lakes in the high grounds,—smoothed hummocks and ridges of rock in the valleys, with the exposed side towards the supposed sources of the glaciers, and trains of brown debris in the opposite direction,—and blocks of the gneissic platform of the country carried in the latter direction over the crust of old red sandstone on the coast. The direction of the striation in these instances, is different from that above described, and at one place, on the skirts of Canisp mountain, above a valley containing many moraines, the normal striation from the north-west is crossed, like the chequers of cloth, by another system traceable to an agent which has passed right down hill.

The author considers these facts as indicating that there has been, *first*, a general sweeping of the surface in that district by some icy agent, which has come from the north-west, and been all but wholly indifferent to the inequalities of the ground; and, *second*, systems of local glaciers which have passed over certain portions of the ground, substituting their own peculiar set of tracings and memorials for those of the previous movement. And thus he considers himself as having obtained a key to much that was perplexing in the glacial phenomena of the southern portions of the Highlands. Having in Lochaber,—where Mr Maclaren had found in the valleys traces of a westerly movement,—seen on the higher grounds the clearest memorials of one to the south-eastward and eastward, he believes that the former instances are merely results of later and more local glaciation, the direction of which was of course determined by the descent of the valleys; while it remains true of this, as of the more northern districts, that a general sweeping of the surface, irrespective of hill and valley, had taken place at an earlier period. The author conceives that the smoothings of valleys still more to the southward,

as those of the Gareloch, discovered by Mr Maclaren, and those of Loch Lomond and Loch Katrine, discovered by himself, as well as those of the valley of the Forth, may all be classed under the earlier and more general glaciation, though not perhaps in any place free from some interferences of the later and more local movements. He asserts that every part of the Highlands, and much of the Lowlands, bear traces of this general glaciation, in the rounding and smoothing of rocks, though in many instances, the effects are comparatively obscure, in consequence of weathering, and the washing of the rock-surface by superficial accumulations. The author indicated a new kind of memorial of these glacial operations, in what he described as *Mouldings*, seen on the sides of many hills in Scotland, generally nearly horizontal, resembling the mouldings produced in wood by the use of a curve-edged plane, and which he considers as connecting themselves on the one hand, with such longitudinal ridges as the Garleton Hills, all lying in the direction of the striation of the district; and, on the other, with the rounded and flowing outlines of such larger hills as the Pentlands, on which they are themselves marked. The whole phenomena, in the opinion of the author, demand the passage, over large areas of unequal country, of some agent at once plastic and fitted to apply with keen abrading force to the surface; at the same time in such volume as to fill valleys several miles in breadth, and from one to two thousand feet in depth. He contended that, as respects all these glacial phenomena, Scotland is in precisely the same condition as Scandinavia, where there are proofs of a general movement from the north-west, though turning easterly in the southern district; the valleys on the shores of the Northern Ocean, and White Sea, which shewed proofs of glaciation in the seaward direction, being seats of comparatively modern and local glaciers. The same doctrine applied to North America.

In speculating on the nature of the agent, the author could not profess to speak with much confidence; but he thought that, in dismissing the disproved Dilatation Theory of Charpentier and Agassiz, it would be well to keep in view, that there was no theoretical objection to a flow of glacier ice over wide areas of small inclination, if the latter circumstance were compensated by the volume of the mass; and it even appeared that, on the hydrostatic principle, an accumulation of the materials in one quarter, would cause a movement towards any other quarter offering sufficiently small resistance. The

agent, however, appeared to have been applied in different conditions from a subaerial glacier, at least as far as Scotland was concerned, for the boulder clay of many districts of our country must be considered as the detritus of this general glaciation; and that shewed, in the author's opinion, proofs of the presence of water, both in the compactness of the clay, and in the roundedness of the boulders. Glacier ice moving on a flat surface, even supposing no sea present, would obviously be different from a glacier in a sloping valley, because it would not undergo the same drainage of the included water. It would be in a comparatively slushy condition; and, by the way, so much the more mobile.

The latter part of the paper was devoted to a summary of ascertained facts regarding the superficial accumulations of different countries. The Drift of the Silurian region, described by Sir Roderick Murchison, answered to the Scottish Boulder Clay, in the local character of the included blocks, and the direction in which it had moved. Over and posterior to it, was the Northern Drift, so widely spread in England. This probably corresponded with a second boulder clay or Till, known to Scottish geologists, and which, differing in some respects from the first, might be presumed to be owing to somewhat different causes, or to similar agents operating under different circumstances, the sea being here undoubtedly concerned. The local glaciers of Wales have already been shewn to be later than this drift. In clays and sands below and above the second boulder clay, are found, in Scotland, deposits of shells of living species, but betraying an Arctic character.

The following Gentlemen were duly elected as Ordinary Fellows:—

1. Alex. James Russell, Esq., C.S.
2. Dr Andrew Fleming, H.E.I.C.S., Bengal.

The following Donations to the Library were announced:—

Journal of the Statistical Society of London. Vol. XV., Parts 1, 2, 3. 8vo.—*From the Society.*

Journal of the Horticultural Society of London. Vol. VII., Parts 2 & 3. 8vo.—*From the Society.*

Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. N.S. Nos. 37 & 38. 8vo. —*From the Society.*

Quarterly Journal of the Chemical Society. Vol. V., Nos. 2 & 3. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society. Vol. VIII., Parts 2, 3, 4. 8vo.

Address delivered at the Anniversary Meeting of the Geological Society of London, on the 20th of February 1852. By William Hopkins, Esq. 8vo.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. V., Part 2. 8vo. —*From the Society.*

Journal of the Asiatic Society of Bengal. N.S. Nos. 46, 50, 51, 52, 53, 54. 8vo.—*From the Society.*

Transactions of the Achitectural Institute of Scotland. Vol. II., Parts 3, 4, 5. 8vo.—*From the Institute.*

The Assurance Magazine, and Journal of the Institute of Actuaries. Nos. 6, 8, 9. 8vo.—*From the Institute.*

Scientific Memoirs, selected from the Transactions of Foreign Academies of Science and learned Societies. Edited by Richard Taylor, F.S.A. Vol. V., Part 20. 8vo.—*From the Editor.*

Address at the Anniversary Meeting of the Royal Geographical Society, 24th May 1852. By Sir R. I. Murchison. 8vo.

Catalogue of the Library of the Royal Geographical Society. 8vo. —*From the Society.*

Proceedings of the Royal Irish Academy. Vol. IV., Parts 2 & 3. Vol. V., Part 1. 8vo.—*From the Academy.*

Annals of the Lyceum of Natural History of New York. Vol. V., Nos. 3–14. 8vo.—*From the Lyceum.*

Medico-Chirurgical Transactions. Published by the Royal Medical and Chirurgical Society of London. Vols. XXIV. & XXV. 8vo.— *From the Society.*

Proceedings of the Philosophical Society of Glasgow. 1851–2. Vol. III., No. 4. 8vo.—*From the Society.*

Nineteenth Report of the Scarborough Philosophical Society. 1850. 8vo.—*From the Society.*

Twenty-ninth Annual Report of the Royal Asiatic Society of Great Britain and Ireland. 1852. 8vo.—*From the Society.*

Nineteenth Annual Report of the Royal Cornwall Polytechnic Society. 1851. 8vo.—*From the Society.*

Annual Reports of the Leeds Philosophical and Literary Society. 1832–52. 8vo.—*From the Society.*

Proceedings of the American Association for the Advancement of Science. 1848, 1850, 1851. 8vo.—*From the Association.*

A Notice of the Origin, Progress, and Present Condition of the Academy of Natural Sciences of Philadelphia. By W. S. W. Ruschenberger, M.D. 8vo.—*From the Academy.*

Collection of Reports from the Secretary of the Treasury of the American Government on scientific subjects. 8vo.—*From the American Government.*

Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. V., Nos. 10 & 12. Vol. VI., Nos. 1 & 2. 8vo.—*From the Academy.*

Exploration and Survey of the Valley of the Great Salt Lake of Utah, including a reconnoissance of a new route through the Rocky Mountains. By Howard Stansbury, Capt. T.E., U.S. Army. With Plates. 8vo.—*From the Author.*

The Mastodon Giganteus of North America. By John C. Warren, M.D. 4to.—*From the Author.*

Regi Magyar Nyelvemlékek. Kötet. 1, 2, 3. 4to.

A' Magyar Tudós Társásag' Evkönyvei. Kötet. 3, 4, 6, 7. 4to.

Hunyadiak Kora Magyarországou. irta Gróf Teleki Jozsef. 1 Kötet. 8vo.—*From the Literary Society of Hungary.*

Fifth Annual Report of the Board of Regents of the Smithsonian Institution for 1850. 8vo.

On Recent Improvements in the Chemical Arts. By Prof. James C. Booth and Campbell Morfit. 8vo.—*From the Institution.*

Catalogue of Stars near the Ecliptic, observed at Markree during the years 1848, 1849, & 1850, and whose places are supposed to be hitherto unpublished. Vol. I. 8vo.—*From H. M. Government.*

Proceedings of the American Philosophical Society. Vol. V., No. 47. 8vo.—*From the Society.*

Catalogue of the Library, and Constitution and Laws of the Institute of Actuaries of Great Britain and Ireland. 8vo.—*From the Institute.*

Mémoires présentés pars divers Savants à l'Académie des Sciences

de l'Institut National de France. Sciences Mathématiques et Physiques. Tome XIIIme. 4to.—*From the Academy.*

Recherches sur la Conductibilité des Minéraux pour l'Electricité Voltaïque. Par M. Elie Wartmann. 4to.—*From the Author.*

Flora Batava. 16 Aflev. 4to.—*From the King of the Netherlands.*

Historische en Letterkundige Verhandelingen van de Hollandsche Maatschappij der Wettenschappen te Haarlem. Ite Deel. 4to. —*From the Society.*

Nieuwe Verhandelingen van het Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte te Rotterdam. XIte Deel. 4to.—*From the Society.*

Det Kongelige Danske Videnskabernes Selskabs Skrifter. Femte Række. Naturvidenskabelig og Mathematisk Afdeling. Andet Bind. 4to.—*From the Academy.*

Abhandlungen der Mathematisch-Physischen Classe der Königlich Sächsischen Gesellschaft der Wissenschaften. Band. I. 8vo.—*From the Society.*

Naturwissenschaftliche Abhandlungen, gesammelt und durch subscription herausgegeben von Wilhelm Haidinger. Band IV. 4to.—*From the Editor.*

Archives du Muséum d'Histoire Naturelle, publiées par les Professeurs-Administratifs de cet Etablissement. Tome V., Liv. 4; Tome VI., Liv. 1, 2, 3, & 4. 4to.—*From the Society.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Band. III. 1te. & 3te Lieferungs. Fol.

Sitzungsberichte der Kaiserlichen Akademie der Wissenchaften. Mathematisch-Naturwissenschaftliche Classe. 1851; Band VII., 3, 4, & 5 Hefte: & 1852; Band VIII., 1, 2, 3 Hefte. 8vo.—*From the Academy.*

Almanach der Königliche Akademie der Wissenchaften. 1852. 12o.—*From the Academy.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1851; Nos. 1, 2, 3, & 4. 1852; No. 1. 8vo.—*From the Association.*

Mémoires de la Société Nationale des Sciences d'Agriculture et des Arts de Lille. Année 1850. 8vo.—*From the Society.*

Die Fortschritte der Physik im Jahre 1848. Dargestellt von der

Physikalischen Gesellschaft zu Berlin. 8vo.—*From the Society.*

Bulletin de la Société de Géographie. 4me Série. Tomes II. & III. 8vo.—*From the Society.*

Manuel de la Navigation à la Côte Occidentale d'Afrique. Par M. Charles Philippe de Kerhallet. 2 Tomes. 8vo.

Annales Hydrographiques, Recueil d'Avis, Instructions, Documents et Mémeires relatifs á l'Hydrographie et à la Navigation, publié par le Dépôt-Général de la Marine. Tomes 4me & 5me. 8vo.—*From the Dépôt-Général de la Marine, Paris.*

Tafeln zur Reduction der in millemetern abgelesenen Barometerstände auf die Normaltemperatur von 0° Celsus. Berechent von J. J. Pohl & J. Schabus. 8vo.

Tafeln zur Vergleichung und Reduction der in verschiedenen Längenmassen Abgelesenen Barometerstände. Von J. J. Pohl & J. Schabus. 8vo.—*From the Authors.*

Transactions of the Royal Irish Academy. Vol. XXII., Parts 1 & 2. 4to.—*From the Academy.*

American Journal of Science and Arts. Vol. XIV., No. 42. 8vo. —*From the Editors.*

Smithsonian Contributions to Knowledge. Vols. III. & IV. 4to. —*From the Smithsonian Institution.*

Schoolcraft's History of the Indian Tribes. Part II. 4to.—*From the American Government.*

Astronomical Observations made at the Royal Observatory, Edinburgh, by the late Thomas Henderson, Esq. Reduced and edited by Charles Piazzi Smyth, Esq. Vol. X. 1844-5-6-7. 4to.—*From the Observatory.*

Monday, 20th December 1852.

DR CHRISTISON, Vice-President, in the Chair.

The following Communication was read :—

On the supposed occurrence of Works of Arts in the Older Deposits. By James Smith, Esq. of Jordanhill.

The author, after mentioning various cases of this nature, in all of which the evidence was very defective, exhibited a tool of wrought-iron, said to have been found in the coal, but which was only proved to have come out of a coal-pit.

He then shewed an Indian arrow-head in a calcareous deposit *in situ* from Canada, which, at first sight, might be supposed to be coeval with the formation of the deposit ; but on examination, the calcareous mass proved to be quite superficial, so that nothing could be easier than for the arrow-head, which is of the usual Indian form, to have fallen on the wet surface, and to have been thus apparently imbedded. The author concluded that no evidence had yet been adduced to prove the occurrence of works of art in any of the older deposits.

Tuesday, 4th January 1853.

DR MACLAGAN in the Chair.

The following Communications were read :—

1. On the Optical Phenomena and Crystallization of Tourmaline, Titanium, and Quartz, within Mica, Amethyst, and Topaz. By Sir David Brewster, K.H., D.C.L., F.R.S., and V.P.R.S. Edin.

1. The first part was on the distribution of *Tourmaline in Mica.*—When liquids or gases have been confined in mica, they have often easily escaped and spread between the plates. Crystals, both of tourmaline and quartz, are found in mica, contemporaneous with it, and of considerable size. Such crystals generally have the faces of the hexagonal prism parallel to the laminæ of the mica.

But other crystals of tourmaline formed subsequently, and between the laminæ, are very different. They are hexagonal plates, with faces perpendicular to the axis of the prism. Some of the fluid which deposited them has penetrated between the laminæ, and there

deposited hexagonal plates, often in circular groups round the cavity. The centre of the cavity is occupied by a granular opaque group of crystals. The hexagonal plates are commonly of a brownish yellow, and, if thicker, green; but they are of extreme thinness. Some of them exhibit dichroism by polarized light.

The effects of pressure are detected on the mica near the cavities, proving the force exerted.

The plates of mica exhibit Newton's rings on certain circular spaces, indicating the presence of air or gas between the laminæ; and it is curious that wherever a cavity has projected liquid or gas, it is situated on the circumference of one of these round spots. This indicates that a gas has been projected between the laminæ.

The author then described a remarkable specimen, given him by Dr Fleming, in which very thin hexagonal crystals of tourmaline, in mica, were almost opaque. There are rectilineal cracks in them, however; and these, on looking at the sun through the crystals, exhibit very beautiful optical phenomena. These fissures prove that the crystals were soft after they had their present form. No cavity appears in this specimen.

This specimen, as well as others, contained the filaments and sporules of *Penicillium glaucum* between the laminæ.

2. *On Titanium in Mica.*—Titanium occurs in mica, and often in beautiful dendritic forms, mostly opaque, but when $\frac{1}{2000}$th of an inch thick, transparent. When only a very thin film of mica is left over them, the most beautiful colours are seen, due to the thin plate of mica, and not to a vacuity.

3. *On the occurrence of Quartz in Mica.*—The quartz occurs with its axis of double refraction parallel to the laminæ, but it never occurred in regular crystals.

4. *On Titanium in Amethyst.*—The titanium was found in fine pyramidal crystals, coating the faces as with a powder, but covered again with amethyst faces parallel to those within. The dust was formed of spicular crystals crossing each other at angles of 60° and 30°.

It would appear that the crystals of amethyst must have grown in a solution which at times contained titanium, and at other times did not. Hence the successive layers as the crystals grew. In one case, the titanium formed the external surface in part of the faces of the pyramid, as if the other part had lain in a liquid protected from the deposit, and no more amethyst had afterwards been deposited.

5. *On Titanium in Topaz.*—A number of imperfect crystals of

topaz contained titanium of a scarlet colour and transparent. These had seven different forms, some of them very curious, which are figured.

6. *On Crystals and Cavities in Garnet.*—These are very frequent, and exhibit very singular phenomena by polarized light. The cavities are sometimes surrounded by spaces or sectors of polarized light, indicating that the garnets had been soft after assuming their present forms.

In one case, a liquid or gas had escaped from a cavity, and had left circular crystals of singular beauty.

2. On the Absolute Zero of the Perfect Gas Thermometer; being a Note to a Paper on the Mechanical Action of Heat. By W. J. Macquorn Rankine, Esq.

Temperature being measured by the pressure of a perfect gas at constant density, the absolute zero of temperature is that point on the thermometric scale at which, if it were possible to maintain a perfect gas at so low a temperature, the pressure would be null.

As no gas is entirely devoid of cohesion, the immediate results of experiment give only approximations to the position of this absolute zero. These approximate positions approach nearer to the true position as the gas is rarefied.

The author having deduced the true position of the absolute zero from M. Regnault's experiments on atmospheric air and carbonic acid, soon after their publication, announced the result in the Edinburgh New Philosophical Journal for July 1849, and in the Transactions of the Royal Society of Edinburgh, vol. xx.

The present paper gives the details of the method of determination which he adopted, and a copy of the diagram which he used.

The following were the results arrived at:—

The absolute zero of the perfect gas thermometer is

$$\left.\begin{array}{l} 274^\circ\!\cdot\!6 \text{ centigrade, or} \\ 494^\circ\!\cdot\!28 \text{ Fahrenheit,} \end{array}\right\} \text{below the temperature of melting ice.}$$

The coefficient of expansion of a perfect gas, in fractions of its volume at the temperature of melting ice, is consequently,—

$$\text{Per degree of the centigrade scale, } \frac{1}{274\cdot6} = 0\cdot00364166.$$

$$\text{Per degree of Fahrenheit's scale, } \frac{1}{494\cdot28} = 0\cdot00202314.$$

The following Gentlemen were duly elected as Ordinary Fellows:—

1. Major EDWARD MADDEN, H.E.I.C.S.
2. Dr JAMES WATSON, of Bath.
3. Lieutenant ROBERT MACLAGAN, Bengal Engineers.

The following Donations to the Library were announced:—

Memorie della Reale Accademia delle Scienze di Torino. Serie 2da. Tomo XII. 4to.—*From the Academy.*

Acta Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosarum. Vol. XXIII., Pars II. 4to.—*From the Academy.*

Transactions of the Linnæan Society of London. Vol. XXI., Part 1. 4to.

Proceedings of the Linnæan Society of London. Feb. 4, 1851, to March 16, 1852. 8vo.—*From the Society.*

Abhandlungen der Akademie der Wissenschaften zu Berlin. 1850. 4to.—*From the Academy.*

Monday, 17*th January* 1853.

RIGHT REV. BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. On a simplification of the Instruments employed in Geographical Astronomy. By Prof. C. Piazzi Smyth.

These instruments include all of that smaller class employed by travellers and navigators in determining latitudes and longitudes, and in making surveys.

At sea, the only instrument which can be employed, is some form of the double-reflection instrument, as the sextant, or rather the reflecting circle; and as this is able to compass all the requirements which may be made of it there, great advantage will result in economy, portability, and despatch, if it can be made also to serve the purposes of a traveller by land.

Hitherto, however, this has been accomplished but very inefficiently; for with all the assistance of artificial reflecting horizons

and stands,—generally of a singularly unpractical character,—the reflecting circle is only enabled to measure inclined angles and altitudes within very circumscribed limits.

Any traveller, therefore, who wishes to be prepared for every opportunity for observation, has further to load himself with a theodolite for horizontal angles, with a vertical circle for altitudes between 0° and 10°, and between 60° and 90°; with a transit instrument for transit observations; and with an independent telescope for observations of eclipses, occultations, &c.

The author, however, by employing his particular form of the marine reflecting circle, viz., the Edinburgh reflecting circle,—which is even more efficient and convenient at sea than the ordinary form,—and by placing it on a stand of peculiar construction, converts it at once into an altitude and azimuth instrument of a most simple effective character; capable of being employed as any of the above instruments, and with some practical advantages in facility of observing and reading off.

To this combination, therefore, of the naval circle with a stand for land use, he proposed to give the name of the Edinburgh Universal Instrument, and hoped that it might facilitate and promote the observations of geographical astronomy amongst the explorers in distant lands.

2. On the Mechanical Action of Heat, Section VI.:—A review of the Fundamental Principles of the Mechanical Theory of Heat; with remarks on the Thermic Phenomena of Currents of Elastic Fluids, as illustrating those Principles. By W. J. Macquorn Rankine, Esq.

This section contains four sub-sections, the first three of which constitute a review of the fundamental principles of the Mechanical Theory of Heat, which are investigated by a method different from any that has been hitherto employed; while the fourth contains the application of those principles to the determination of the inferences to be drawn from the recent experiments of Mr Joule and Prof. William Thomson on the thermic phenomena exhibited by currents of air rushing through small openings.

In the *First Sub-Section*, the author abstains not only from assuming any hypothesis respecting the nature of heat, or the constitution

of matter, but also from taking into consideration the nature, or even the existence, of any such function as temperature. The theorems and formulæ obtained are simply the necessary consequences of the following

DEFINITION OF EXPANSIVE HEAT :—

Let the term Expansive Heat be used to denote a kind of Physical Energy convertible with, and measurable by, equivalent quantities of Mechanical Power, and augmenting the Expansive Elasticity of matter in which it is present.

The conclusions arrived at are applicable to the mutual transformation, not merely of heat and expansive power, but, *mutatis mutandis*, of any two forms of physical energy, known or unknown, one of which is actual, and the other potential.

Let a body whose volume is V, possess the quantity of heat Q, and let its expansive pressure be P. Let it expand from V to V + d V, so that the total expansive power developed is P d V. Then *the latent heat of expansion* during this operation, or the heat which disappears by being converted into expansive power, is

$$Q \frac{d\,P}{d\,Q} d\,V$$

The excess of this above the actual power developed, viz.—

$$\left(Q \frac{d\,P}{d\,Q} - P \right) d\,V$$

is expended in overcoming cohesive force.

When the total quantity of heat in the body increases by d Q, and its volume by d V, the amount of heat which it must receive is made up of the following parts :—

Heat which remains in the body in its original form, increasing the total heat, ... $d\,Q$

Heat expended in producing molecular changes, independent of change of volume, ... $\left(f'.Q + Q \frac{d^2 \int P\,d\,V}{d\,Q^2} \right) d\,Q$

Latent heat of expansion, as before, . $Q \frac{d\,P}{d\,Q} d\,V$

The entire amount being

$$d\,.\,Q = \left(1 + f'\,.\,Q + Q \frac{d^2 \int P\,d\,V}{d\,Q^2} \right) d\,Q + Q \frac{d\,P}{d\,Q} d\,V$$

If from this be subtracted the power developed, $P\,d\,V$, there remains the expression of the energy received by the body on the whole; that is, the difference between the energy received and the energy given out, viz.—

$$d\,\Psi = d\,.\,Q - P\,d\,V =$$
$$\left(1 + f'\,.\,Q + Q\frac{d^2 \int P\,d\,V}{d\,Q^2}\right) d\,Q + \left(Q\frac{d\,P}{d\,Q} - P\right) d\,V$$

This quantity is a complete differential, its integral being

$$\Delta\,.\,\Psi = \Delta\,.\left(Q + f\,.\,Q + \left(Q\frac{d}{d\,Q} - 1\right)\int P\,d\,V\right)$$

When the expansive power $P\,d\,V$ is wholly expended in moving the particles of the expanding body itself, that motion being ultimately extinguished and converted into heat by friction, the above quantity, $d\,\Psi$, represents the entire quantity of heat which the body has consumed at the end of the process.

In a machine producing power by the alternate expansion and contraction of a body under the influence of heat, let Q_1 and Q_2 represent the greatest and least quantities of heat possessed by the body. Then, to work to the best advantage, the body must receive heat and convert it into expansive power at the constant heat Q_1, and give out heat by compression at the heat Q_2, when the ratio of the heat converted into power to the total heat expended will be

$$\frac{Q_1 - Q_2}{Q_1}$$

In the *Second Sub-Section*, the author, still abstaining from the use of any hypothesis, investigates such properties of temperature as are deducible from the following

DEFINITION OF EQUAL TEMPERATURES:—

Two portions of matter are said to have Equal Temperatures, when neither tends to communicate heat to the other.

Hence immediately follows a

COROLLARY.

All bodies absolutely destitute of heat have equal temperatures.

The ratio of the real specific heats of two substances being defined to be the ratio of the quantities of heat which equal weights of them possess at equal temperatures, the following *Theorem* is proved:—

The ratio of the Real Specific Heats of any pair of substances is the same at all temperatures.

Symbolically, let τ denote the temperature of a body; κ the temperature of absolute privation of heat; $\mathfrak{k}$, a function of the nature, and possibly of the density of the body. Then the quantity of heat in unity of weight may be expressed thus—

$$Q = \mathfrak{k}\,(\psi . \tau - \psi . \kappa)$$

If this notation be introduced into the expression for the greatest proportion of heat convertible into mechanical power by an expansive engine, it becomes

$$\frac{Q_1 - Q_2}{Q_1} = \frac{\psi . \tau_1 - \psi . \tau_2}{\psi . \tau_1 - \psi . \kappa}$$

that is to say, this ratio is a function merely of the temperatures of receiving heat, τ_1, and of emitting heat, τ_2, and independent of the nature of the body. This is *Carnot's Theorem*, as modified by Messrs Clausius and Thomson. The expression for the latent heat of expansion becomes

$$Q \frac{d\,P}{d\,Q} d\,V = \frac{\psi . \tau - \psi . \kappa}{\psi' . \tau} \cdot \frac{d\,P}{d\,\tau} d\,V$$

$$= \frac{J}{\mu} \cdot \frac{d\,P}{d\,\tau} d\,V, \text{ in Prof. Thomson's notation.}$$

Hence, in Professor Thomson's notation,

$$Q = \mathfrak{k}\, e^{\frac{1}{J}\int \mu\, d\,\tau}$$

which, being introduced into the formulæ of the first sub-section, reproduces all his formulæ.

In the *Third Sub-Section*, the author points out the consequences peculiar to the Hypothesis of Molecular Vortices (that is to say, of whirling eddies in elastic atmospheres surrounding atomic nuclei); an hypothesis, the first outline of which was given by Sir Humphry Davy, and which the author adopted, with modifications and additions, as the basis of his investigations in the first five sections of this paper, in two papers on the Centrifugal Theory of Elasticity, and in other papers, with a view to the deduction of the laws of heat and elasticity from the principles of mechanics. After pointing out the resemblances and differences between this hypothesis and that of Molecular Collisions proposed by Messrs Herapath and Waterston, and remarking that the Hypothesis of Molecular Vortices, besides re-

presenting successfully the theory of expansive heat, is consistent with that of radiant heat and light, and well adapted to form a basis for that of the elasticity of solids, the author shews, by a method more simple than those formerly employed by him, that, according to this hypothesis, the pressure of a perfect gas is represented by

$$P = (NQ + h)\frac{1}{V}$$

N and h being specific coefficients. Let V_0 be the volume of unity of weight of a perfect gas at a standard pressure P_0, and temperature τ_0; then absolute temperature, as measured by a perfect gas thermometer, has this value—

$$\tau = \tau_0 \frac{P\,V}{P_0\,V_0} = \frac{\tau_0}{P_0\,V_0}\,(NQ + h)$$

The absolute temperature of total privation of heat is

$$\varkappa = \frac{\tau_0\, h}{P_0\,V_0}$$

The quantity of heat in unity of weight of a body is

$$Q = \mathfrak{k}\,(\tau - \varkappa)$$

where

$$\mathfrak{k} = \frac{P_0\,V_0}{N\,\tau_0}$$

is the coefficient of real specific heat.*

The introduction of this value of heat in terms of temperature into the equations of the first sub-section, reproduces all the formulæ which were deduced directly from the hypothesis in the author's previous researches. In particular, the greatest proportion of heat convertible into mechanical power in an expansive engine working between the temperatures τ_1 and τ_2, is

$$\frac{\tau_1 - \tau_2}{\tau_1 - \varkappa}$$

The value of f (Q) is

$$\mathfrak{k}\,N\,\varkappa\left(\text{hyp. log}\,\tau + \frac{\varkappa}{\tau}\right)$$

In the *Fourth Sub-Section*, the author investigates the inferences to be drawn from the experiments of Messrs Joule and Thomson.

* These conclusions have since been confirmed by M. Regnault's experiments on the Specific Heat of Gases. (See *Comptes Rendus*, 1853, and Philos. Mag., June 1853.)

If a gas in a compressed state be allowed to expand by rushing through small apertures, so that the expansive power developed shall all be converted, first, into tangible motion, and then by friction into heat, while the gas gives out no mechanical power to other bodies, and neither receives nor gives out heat, its condition is expressed by the following equation:—

$$0=\Delta\,\Psi=\Delta\,.\,\left\{\dot{Q}+f(Q)+\left(Q\frac{d}{dQ}-1\right)\int P\,dV\right\}$$

$$=\mathfrak{k}\,\Delta\,\tau+\Delta\int\left(\tau\frac{dP}{d\tau}\ -\ \right)d\,V$$

$$-\kappa\left\{\Delta\int\frac{dP}{d\tau}\,d\,V-\mathfrak{k}\,N\,\left(\Delta\,.\frac{\kappa}{\tau}+\Delta\ \text{hyp.}\log\tau\right)\right\}.$$

The cooling effect of a given expansion in atmospheric air, $-\Delta\tau$, has been the subject of experiment. The term

$$\Delta\int\left(\tau\frac{dP}{d\tau}-P\right)d\,V$$

which represents the heat expended in overcoming molecular attraction, is calculated by means of formulæ deduced by the author from M. Regnault's experiments, with the aid of the hypothesis, as well as the function by which κ is multiplied. Thus each series of experiments supplies data for computing an approximate value of κ, the absolute temperature of total privation of heat. The values of κ thus calculated from ten series of experiments, range from 1°·08 to 2°·345 centigrade. The greatest discrepancy is therefore 1°·265 centigrade, which would cause a maximum error of only one three-hundredth part in calculating the power of any expansive engine. The values of κ are both largest, and agree best together, for those experiments in which the quantity of air used was greatest, and therefore the risk of error least. The author considers that the experiments prove the formulæ deduced from the Hypothesis of Molecular Vortices to be at least sufficiently correct for practical purposes; that they afford a strong probability of the theoretical soundness of the hypothesis; and that the position of the *absolute zero of heat* is nearly as follows:—

	Centigrade.	Fahren.
Above absolute zero of a perfect gas thermometer, .	2°·1	3°·78
Below the temperature of melting ice, ...	272°·5	490°·5

The paper concludes with formulæ for future use in reducing experiments on Carbonic Acid Gas.

The following Donations to the Library were announced:—

Flora Batava. Part 171. 4to.—*From the King of Holland.*

The Assurance Magazine, and Journal of the Institute of Actuaries. No. 10. 8vo.—*From the Institute.*

Journal of the Horticultural Society of London. Vol. VII., Part 4; Vol. VIII., Part 1. 8vo.—*From the Society.*

Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tom. XXVI. 4to.

Mémoires Couronnés et Mémoires des Savants Etrangers, publiés par l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tome XXIV. 4to.

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tomes XVII.–XIX. (1850–1852.) 8vo.

Annuaire de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tomes XVII.–XIX. (1851 and 1852.) 12°.

Mémoires Couronnés et Memoires des Savants Etrangers, publiés par l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Collection in 8°. Tome V.—*From the Academy.*

Annales de l'Observatoire Royal de Bruxelles, publiées aux frais de l'Etablissement, par le Directeur, A. Quételet. Tomes VIII. et IX. 4to.

Annuaire de l'Observatoire Royal de Bruxelles, par A. Quételet. 1851 & 1852. 12°.—*From the Editor.*

Résumé des Observations sur la Météorologie et sur le Magnetisme Terrestre faites à l'Observatoire Royal de Bruxelles en 1850, et communiquées par le Directeur, A. Quételet. 4to.—*From the Author.*

The Canadian Journal; a Repertory of Industry, Science, and Art, and a Record of the Proceedings of the Canadian Institute. October and December 1852. 4to.—*From the Institute.*

Journal of the Royal Geographical Society of London. Vol. XXII. 1852. 8vo.—*From the Society.*

Catalogue Méthodique de la Collection des Reptiles. Muséum d'Histoire Naturelle de Paris. 8vo. Catalogue Méthodique de la Collection des Mammifères de la Collection des Oiseaux.

Muséum d'Histoire Naturelle de Paris. 8vo.—*From the Museum.*

Berichte über die Verhandlungen der Königlich Sachsischen Gesellschaft der Wissenschaften zu Leipzig. (1848.) 8vo. Bande I., II., III.—*From the Society.*

Catalogue des Manuscrits et Hylographes Orientaux de la Bibliothèque Impériale Publique de St Pétersbourg. 8vo.—*From the Russian Government.*

Monday, 7th February 1853.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Structural Characters of Rocks. By Dr Fleming.

While the condition of the mineral masses in the neighbourhood of Edinburgh furnish interesting illustrations of the structural characters of rocks, such as the columnar, the concretionary, and the fragmentary, &c., the author proposed to confine his remarks at present to what he denominated the FLAWED STRUCTURE.

In the ordinary language of quarriers, the *flaws* are termed *backs*, while they are known to masons as *dries*, and to geologists, when referred to, as *slicken-sides*. This last term, independent of its provincial character, refers to one peculiar form of the flaw only, and, although explicable according to the same views entertained respecting the origin of the others, is far from being a typical form. The *flaw* of the lapidary, in reference to crystals or gems, comes sufficiently near in character to justify its adoption.

The FLAW is a crack which is confined to the stratum or bed in which it occurs, and is thus distinguished from *fault* or dislocation, since these extend through several beds. It occupies all positions in the bed, without an approach to parallelism, the flaws being variously inclined to one another, and not extending continuously throughout the thickness of the bed; thus differing from the *columnar structure.*

These flaws are sometimes isolated; in other cases two unite at

angles more or less acute, and the junction edges are either sharp or rounded. The surface of the sides of the flaw is frequently crumpled or waved, and in the granularly-constituted beds, such as granite, porphyry, or sandstone, is rough, while in slate-clay, bituminous shale, and steatite, it often exhibits a specular polish.

The circumstance of the flaws exhibiting no approach to parallelism, joined to the fact that they are not prolonged into the inferior or superior beds, nay, frequently not extending throughout the bed containing them, furnish a demonstration that they were not produced by an external force. The notion, too, is untenable, that the polishing was produced by the faces of the flaw sliding backwards and forwards on one another, because their limited extent, mode of junction, and waved surfaces clearly indicate the absence of any such alternate shifting.

The author then stated his opinion that the flaws had been produced by *shrinkage*, owing to the escape of volatile matter, aided by molecular aggregation, and that the polished surfaces were produced in comparatively soft plastic matter, like bituminous shale, by the presence of water or gas in the cavity, so that the specular character was the *casting* or impression of a liquid surface. The empty vesicles of amygdaloid are occasionally found glossy on the walls, or exhibiting an apparently vitrified film, while the rock itself is dull and earthy in fracture. The smoothness in this instance is probably produced as the casting or impress of included vapour or gas. Sometimes the flaws in coarse materials, such as porphyry, have a specular aspect, owing to a film of anhydrous peroxide of iron. Illustrative examples were exhibited, and references to various localities around Edinburgh, where the whole phenomena of *flawed* structure were well displayed.

2. Observations on the Speculations of the late Dr Brown, and of other recent Metaphysicians, regarding the exercise of the Senses. By Dr Alison.

The object of this paper was to recal attention to the celebrated controversies on this subject, carried on during the last century; chiefly because some expressions used by Dr Brown, by Lord Jeffrey, Sir James Mackintosh, and M. Morell, convey the impression that the doctrines of Reid and Stewart on this essential part of their system of Metaphysics, are now generally neglected or abandoned.

The author endeavoured to shew, on the contrary, that the existence and authority of what Reid called Principles of Common Sense, and Stewart called Fundamental Laws of Belief, and Brown called Principles acquired by Intuition, as *ultimate facts* in the constitution of the human Mind; and farther, the necessity of reference to such principles, in any account that can be given of the information acquired by the Senses,—is admitted by all those authors, and must be regarded as an established first principle in this science. He stated that the only real addition made to our knowledge of this subject by Dr Brown, consisted in his pointing out the province of the *muscular sensations*, as distinguished from those produced by impressions on the *cutaneous nerves*, in suggesting to us the notions of the Primary qualities of Matter; and that his doctrine as to the manner in which the idea of external independent existence is suggested to the mind, is substantially the same as that previously proposed by Turgot, and adopted by Stewart, and strictly consistent with the statements of Reid.

He maintained farther, that when Dr Brown and other more recent authors, supposed that they had detected an error in the reasonings of Reid and Stewart against the scepticism of Berkeley and Hume, they had deceived themselves; *first*, Because they stated the object of Reid to be, to prove, by *argument*, the independent existence of the material world, which he had expressly disclaimed; *secondly*, Because they stated the substance of the sceptical argument to be merely the *negative* proposition, that that independent existence cannot be proved by reasoning; whereas it was the *positive* proposition, that the idea of such independent existence involves an absurdity, or contradiction in terms; and, *thirdly*, Because they entirely overlooked *the fact*, on which Reid and Stewart relied, as evidence that the Perceptions, or notions which the mind forms of the qualities of external objects, can be referred only to those fundamental Laws of Belief, which *all admit* as ultimate facts in this department of science;—viz., the *utter dissimilarity* of these Perceptions to the Sensations which introduce them into the mind; from which they argued, not that the objects of Perception have been proved to exist by reasoning, but that there is no more absurdity, or contradiction in terms, in believing that they exist, than in believing in our own identity, or in the suggestions of Memory.

Lastly, the author maintained, that when Reid's doctrine of Per-

ceptions, as distinct from Sensations, is duly reflected on, it will be found to involve all the theological inferences, which Morell and others have supposed to be suggested only by the view of this subject which has been taken by some German metaphysicians; and to be remarkably in accordance with all that has been recently ascertained in regard to the connection of the different Mental acts with the living action of different parts of the Nervous System; and farther, to be quite compatible with the supposition (the evidence of which he considered as still *sub judice*) of Perception taking place, even in this state of human existence, otherwise than by the ordinary exercise of the Senses.

The following Gentlemen were duly elected as Ordinary Fellows:—

1. The Rev. Dr Robert Lee, Professor of Biblical Criticism.
2. J. S. Blackie, Esq., Professor of Greek.
3. The Right Rev. Dr Trower, Bishop of Glasgow, and late Fellow of Oriel College.

The following Donations to the Library were announced:—

Craigie's Practice of Physic. 2 vols. 8vo.—*From the Author.*

Abhandlungen der Akademie der Wissenschaften zu Berlin. 1850 & 1851. 4to.

Monatsbericht der Akademie der Wissenschaften zu Berlin. Juli–Oct. 8vo.—*From the Academy.*

Acta Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosarum. Vol. XXII., Suppl., and XXIII. 4to.—*From the Academy.*

Memorias della Real Accademia de Ciencias de Madrid. Tome I., Part 2. Fol.

Resumen de las Actas della Accademia Real de Ciencias de Madrid. 1850 and 1851. 8vo.—*From the Academy.*

Monday, 21*st February* 1853.

SIR T. M. BRISBANE, Bart., President, in the Chair.

The following Communication was read:—

On the Summation of a Compound Series, and its application to a Problem in Probabilities. By the Right Rev. Bishop Terrot.

The series proposed for summation is

$$
\begin{aligned}
&\overline{m-q}\,.\,\overline{m-q-1}\ldots\overline{m-q+p+1}\times 1\,.\,2\,.\,3\ldots q\\
+&\overline{m-q-1}\,.\,\overline{m-q-2}\ldots\ldots\overline{m-q+p}\quad\times 2\,.\,3\,.\,4\ldots\overline{q+1}\\
&\qquad\vdots\qquad\qquad\qquad\qquad\qquad\vdots\\
+&p\,.\,\overline{p-1}\,.\,\overline{p-2}\ldots\ldots\ldots 1\quad\times\overline{m-p}\,.\,\overline{m-p+1}\ldots\overline{m-p+q+1}
\end{aligned}
$$

In which series each line or term is the product of two factorials, the first consisting of p, the last of q factors of successive numbers. And in each successive term the factors of the first factorial are diminished each by unity, and the factors of the last increased.

The method employed to sum this series is to multiply the sum of all the left-hand factors into the first right-hand factor; the sum of all except the first, into the difference between the first and second of the right-hand factors, and so on; thus reducing the series to the form

$$
\begin{aligned}
&\frac{q}{p+1}\times(\overline{m-q+1}\,.\,\overline{m-q}\ldots\ldots\ldots\overline{m-p+q+1})\times 1\,.\,2\,.\,3\ldots\overline{q-1}\\
+&\frac{q}{p+1}(\overline{m-q}\,.\,\overline{m-q-1}\ldots\ldots\ldots\overline{m-p+q})\times 2\,.\,3\ldots\ldots\ldots q\\
&\quad\&c.\qquad\qquad\qquad\&c.\qquad\qquad\qquad\&c.
\end{aligned}
$$

If this integration on the one side and differentiation on the other be continued for q times, the series is reduced to the single term

$$\frac{q\,.\,\overline{q-1}\,.\,\overline{q-2}\,\ldots\ldots 1}{\overline{p+1}\,.\,\overline{p+2}\ldots\ldots\overline{p+q+1}}\times\overline{m+1}\,.\,m\ldots\ldots\ldots\overline{m-q+p+1}.$$

This summation is applicable to the solution of the problem, Suppose an experiment concerning whose inherent probability of success we know nothing, has been made $\overline{p+q}$ times, and has succeeded

p times and failed q times; what is the probability of success at the $\overline{p+q+1}^{\text{th}}$ trial?

This problem gives four varieties, according as m, the possible number of experiments, is finite or infinite, and according as results effected can or cannot be repeated. If we take the common example of drawing balls, which must be either black or white, from a bag, then results effected may be repeated if the balls are replaced after being drawn; if the balls drawn are not replaced, then the same result cannot be repeated. The only case of the problem which the author of this paper has been able to find solved in any treatise on probabilities, though he must confess that his range of inquiry has not been very large, is that where m is infinite, and the balls drawn are replaced. His object in his paper was to solve the case where m is finite, and the balls are not replaced.

In this case it is manifest that the number of white balls contained in the bag may be any number from $\overline{m-q}$ to p, and the corresponding number of black, any number from q to $\overline{m-p}$. Then, omitting the common constants, the several hypotheses which can be formed as to the proportion of black and white balls in the bag at first, H_1, H_2, H_3, &c., give, for the probability of the event observed, that is, for the drawing of p white and q black balls, the following probabilities:—

$$H_1,\ \overline{m-q}\,.\,\overline{m-q-1}\ldots\ldots\overline{m-q-p+1}\times 1\,.\,2\,.\,3\cdots\cdots q \qquad (\alpha)$$

$$H_2,\ \overline{m-q-1}\,.\,\overline{m-q-2}\cdots\cdots\overline{m-q-p}\times 2\,.\,3\,.\,4\cdots\cdots q+1 \qquad (\beta)$$

and so on for all the other hypotheses. Hence the probability of H_1, which is $\frac{\alpha}{\alpha+\beta+\gamma}$ &c. = (by the preceding summation)

$$\frac{\overline{p+1}\,.\,\overline{p+2}\cdots\cdots\cdots\overline{p+q+1}}{\overline{m+1}\,.\,m\cdots\cdots\cdots\overline{m-p-q+1}\times 1\,.\,2\,.\,3\cdots\cdots q}\times$$
$$\overline{m-q}\,.\,\overline{m-q-1}\cdots\cdots\overline{m-q-p+1}\times 1\,.\,2\cdots\cdots q.$$

Therefore the probability of a white ball at $\overline{p+q+1}^{\text{th}}$ drawing, derived from H_1, is

$$\frac{\overline{p+1}\,.\,\overline{p+2}\cdots\cdots\cdots\overline{p+q+1}}{(\overline{m+1}\,.\,m\cdots\cdots\cdots\overline{m-p-q+1})\times 1\,.\,2\,.\,3\cdots\cdots q}\times$$
$$m-q\,.\,m-q-1\cdots\cdots m-q-p\times 1\,.\,2\,.\,3\cdots\cdots\cdots q.$$

In same way the probability derived from H_2 is the same fraction into

$$(m-q-1\,.\,m-q-2\cdots\cdots m-q-p-1)\times 2\,.\,3\cdots\cdots q+1$$

and so for all the other hypotheses. And summing again this series, we have the whole probability equal—

$$\frac{p+1\,.\,p+2\cdots p+q+1}{(m+1\,.\,m\cdots m-p-q)\times 1\,.\,2\cdots q}\times\frac{1\,.\,2\cdots\cdots q}{p+2\,.\,p+3\cdots p+q+2}\times$$
$$m+1\,.\,m\cdots\cdots\cdots m-p-q=\frac{p+1}{p+q+2}$$

As this expression does not involve m, it follows that when the balls drawn are not replaced, the probability of drawing a white ball at the $\overline{p+q+1}|^{\text{th}}$ trial, depends entirely upon p and q, and is unaffected by the magnitude of m, whether finite or infinite.

The last portion of the paper considers the case where m is given, and the balls drawn are replaced.

It is evident that in this case the main point must be to sum the series

$$\overline{m-1}|^{p}\times 1^{q}+\overline{m-2}|^{p}\,.\,2^{q}\cdots\cdots 1^{p}\,.\,\overline{m-1}|^{q}$$

This was effected by a process similar to that used in the last case, and the sum found to be

$$\Sigma_q\,\overline{m-1}|^{p}+d_2\,\Sigma_q\,\overline{m-2}|^{p}\cdots\cdots\cdots d_{q+1}\,\overline{m-q}|^{p}$$

Where $\Sigma_q\,\overline{m-1}|^{p}$ means the q^{th} integration of the series

$$1+2^{p}\cdots\cdots\overline{m+1}|^{p},$$

and d_1, d_2, d_3, &c., mean the 1st, 2d, 3d terms of the q^{th} row of differences of the series $1_q\,.\,2^q$, &c.

Applying this as was done with the $\alpha+\beta+\gamma$, &c., of the last case, the probability of a white at the $\overline{p+q+1}|^{\text{th}}$ drawing is

$$\frac{\Sigma_{q+1}\,\overline{m-1}_{|p+1}+d_2\,\Sigma_{q+1}\overline{m-2}|^{p+1}\cdots\cdots d_q\,\Sigma_{q+1}\overline{m-q}|^{p+1}}{m\,(\Sigma^{q}\,\overline{m-1}|^{p}+d_2\,\Sigma_q\,\overline{m-2}|^{p}\cdots\cdots d_q\,\Sigma_{q+1}\,\overline{m-q}|^{p})}$$

If m be infinite, this becomes $\dfrac{\Sigma_{q+1}\,m^{p+1}}{m\,\Sigma^{q+1}\,m^{p}}=\dfrac{p+1}{p+q+2}$

The following Gentlemen were duly elected as Ordinary Fellows:—

1. James M. Hog, Esq. of Newliston.
2. The Rev. John Cumming, D.D.

Monday, 7th March 1853.

SIR T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read:—

1. On the Species of Fossil Diatomaceæ found in the Infusorial Earth of Mull. By Professor Gregory.

The author, after some general remarks on the Infusoria generally, and especially on their occurrence in the fossil state, mentioned that the earth in question had been discovered by the Duke of Argyll at Knock, near Aros in Mull, and its geological position briefly described by him to the Society, two years ago. The author had undertaken an examination of it, and had found it to contain, besides Phytolitharia, silicified pollen of grasses and coniferæ, and spicules and gemmules of fresh-water sponges, the unprecedented number of about 60 species of Diatomaceæ. He had consulted the Rev. W. Smith, who had observed in it the following 59 species, all belonging to fresh water, which he named, the names being those of his forthcoming Synopsis, and one species which he cannot at present refer to any known form.

1. Pinnularia......major.
2. „ ......viridis.
3. „ ......oblonga.
4. „ ......divergens.
5. „ ......radiosa.
6. „ ......interrupta.
7. „ ......gibba.
8. „ ......Tabellaria.
9. „ ......gracilis.
10. „ ......acuta.
11. „ ......mæsolepta.
12. „ ......gracilis.
13. „ ......lata.
14. „ ......alpina.
15. Navicula.........rhomboides.
16. „ ....serians.
17. „ ....dicephala.
18. „ ....firma.
19. „ ....angusta.
20. „ ....ovalis.
21. Gomphonema...acuminatum.
22. „ ...*d*. var. β coronatum.
23. Gomphonema Vibrio.
24. „ ...capitatum.
25. Amphora ......ovalis.
26. Stauroneis.....Phœnicenteron.
27. „ ......gracilis.
28. „ ......anceps.
29. „ ......linearis.
30. Cocconeis......Thwaitesii.
31. „ ......Placentula.
32. Surirella ......biseriata.
33. „ ......Brightwellii.
34. Cymbella......Helvetica.
35. „ ......Scotica.
36. „ ......maculata.
37. „ ......affinis.
38. „ ......cuspidata.
39. Cymatopleura elliptica.
40. „ apiculata.
41. Himantidium gracile, *Kütz*.
42. „ Arcus, *Kütz*.
43. „ majus, *W. Sm*.
44. „ pectinale, *Kütz*.

45. Himantidium undulatum, *Ralfs.*
46. „ bidens, *W. Sm.*
47. Tabellaria ......fenestrata, *Kütz.*
48. „ ......ventricosa, *Kütz.*
49. Epithemia......turgida.
50. „ ......gibba.
51. Eunotia.........gracilis.
52. „ ....tetraodon.
53. Eunotia.........Diadema.
54. Synedra........capitata.
55. „ ....biceps.
56. Fragillaria....capucina, *Kütz.*
57. Orthoseira.....orichalcea, *W. Sm.*
58. „ .....nivalis, *W. Sm.*
59. Nitzschia......sigmoidea, *W. Sm.*

The 60th is the unknown or doubtful species, which is from $\frac{1}{800}$ to $\frac{1}{470}$ of an inch long, and has 44 cross striæ in $\frac{1}{1000}$ of an inch. In has generally the form nearly of a narrow plano-convex lens, with two notches near the ends of the plane side. It seems to approach Eunotia arcus (*Kützing*), but requires further investigation. In the mean time, Mr Smith proposes to call it Eunotia incisa.

The Mull earth is characterised by the great abundance of Pinnulariæ, Naviculæ, and Stauroneides; by that of Gomphonema coronatum, of the Cymbellæ, of the Himantidia, Eunotiæ, and Epithemiæ, of Tabellariæ, and of Eunotia incisa.

Its chemical analysis yielded

Silica, ...	70·75
Protoxide of iron, with traces of manganese, and an appreciable amount of phosphoric acid,	15·04
Organic matter, ...	12·36
Water and loss, ...	1·85
	100·00

Its composition renders it probable that it may be useful as a manure. It may also be made to yield an excellent polishing powder.

This earth occurs in a hollow, formerly a small loch in winter and a pool in summer, now drained, lying in a rough piece of ground, a mile or a mile-and-a-half in extent, between Loch Baa and the sea, and about 30 or 40 feet above the sea-level. It rests on gravel, and the gravel rests immediately on the granite of the district. It is impossible to fix precisely the age of the deposit, but, from the species it contains, it is probable that it is not of very recent origin; while yet its epoch must be supposed subsequent to that of the deposition of the gravel in which it is found.

Specimens of the earth, and drawings of a number of the species were exhibited; also specimens of polishing powder made from the earth.

2. On the Production of Crystalline Structure in Crystallised Powders, by Compression and Traction. By Sir David Brewster, K.H., D.C.L., F.R.S., V.P.R.S. Edin.

The author, after alluding to the influence of compression and dilatation in producing the doubly refracting structure in solids of all kinds devoid of it, and in modifying it where it exists, mentioned that the phenomena to be described have no relation to those alluded to.

In experimenting on the *double reflexion* and polarization of light discovered by him in the chrysammates of potash, and magnesia, murexide, and other crystals, he found that they could be spread out on glass by hard pressure, like grease or soft wax; and that in the case of dark powders, he could thus obtain a transparent film, exhibiting double reflexion and polarization from its surface, as well as if it had been a large crystal.

In studying these phenomena under polarized light, he found that the streaks and lines had axes of double refraction, as well as the film composed of them, just as if they were regular crystals. When the substance possessed the new property in perfection, these lines, though very minute, were not formed of insulated particles dragged into a line, but the lines of polarized light were continuous, and the crystallographic as well as the optical axis of the particles, were placed in that line. In other cases, the insulation of the particles was easily seen.

The substance may be subjected to pressure and traction, either on smooth or on ground glass, the latter being preferable for hard substances. A polished and elastic knife is used to give the pressure. The lines thus formed, examined in the polariscope, exhibit regular neutral and depolarizing axes. With the chrysammate of magnesia, the appearances are peculiarly splendid; its natural colours, which vary with the thickness, being combined with the tints depolarized by the streaks. As these crystals are dichroitic, and possess unusual reflexion, so also the streaks exhibit the same; the two pencils being carmine red and pale yellow.

This property the author has found more or less in the following crystals:—

Chrysammate of magnesia.	Murexide.
... potash.	Aloetinate of potash.
Hydro-chrysammide.	Aloetinic acid.

Oxamide.
Palmine.
Palmic acid.
Amygdaline.
Tannin, pure.
Quinine, pure.
... acetate of.
... sulphate of.
... muriate of.
... phosphate of.
... citrate of.
Cacao butter.
Veratric acid.
Esculine.
Theine.
Silver, cyanide of.
... acetate of.
Platinum & magnesium, cyanide of.
.. and barium, cyanide of.
... and potassium, cyanide of.
... ammonia, chloride of.
Potash, chlorate of.
... chromate of.
Urea, nitrate of.
Sulphur.
Camphor.
Cinchonine.
Cinchonine, sulphate of.
Meconic acid.
Brucine, sulphate of.
Morphia, acetate of.
Tin, iodide of.
Cerium, oxide of.
Parmeline.
Lecanorine.
Indigo, red.
Ammonia, oxalate of.
... sulphate of.
Soda, chromate of.
Lead, iodide of.
Strychnine, sulphate of.
... acetate of.
Soda, nitrate of, native.
Berberine.
Mucic acid.
Solanine.
Asparagine.
Mercury, bichloride of.
Isatine.
Alizarine.
Manganese, sesquioxide of.
Lead, protoxide of.
Tungstic acid.
Oxalate of chromium and potash.

In many substances, when subjected to pressure and traction, the particles exhibit no such arrangement into transparent streaks, as in the above, but are merely dragged into lines, and exhibit a quaquaversus polarization. But there is another class, which yields transparent streaks, without any trace of prismatic arrangement. Such are the bodies in the following list :—

Hydrate of potash, pure.
Indigotic acid.
Urea.
Citric acid.
Silver, nitrate of.
Meconine.
Napthaline.
Soda, nitrate of, pure.
Potash and copper, sulphate of.
Soda, phosphate of.
Soda, acetate of.
Mercury, cyanide of.
... chloride of.
... sulphuret of.
Baryta, acetate of.
Zinc, chromate of.
... sulphate, of.
Cobalt, sulphate of.
Magnesia and soda, sulphate of.
Borax.

Compression is, no doubt, the agent which forces the particles into optical contact, and traction draws them into a line, tending to sepa-

rate them in that direction. These forces may possibly modify the doubly-refracting structure, but the author has not examined this question.

On trying certain soft solids which possess double refraction, such as bees' wax, oil of mace, almond soap, and tallow, remarkable results were obtained. Almond soap, the particles of which are not in optical contact, may be drawn out into strings, and these strings possess neutral and depolarizing axes like the streaks above described. This is done by traction alone. Similar results are obtained in oil of mace and tallow, by compression and traction. In bees' wax, the depolarizing lines are even better displayed, especially if a little common resin be added.

It is not easy to explain why, in these experiments, the optical and crystallographic axes of the particles are placed in the same line. Mechanical force is the primary agent, but it is possible that electricity may also contribute, even in the case of almond soap, to the result. In that case, however, by drawing it out into a thread, we diminish all the lateral obstacles to a crystalline arrangement. Elementary prisms, or crystals whose length much exceeds their breadth, will then tend to place their long axes in the line of traction, and as the lateral obstructions are removed, the particles may follow their natural tendency.

We have reason to suppose, that in hard substances the same principle acts, and that the particles, when drawn into narrow lines and freed from lateral attractions, may more readily assume the crystalline arrangement which is natural to them, and is the result of certain inherent polarities.

In some cases, where the crystalline arrangement was imperfectly produced, the author observed a tendency in the particles to quit their position, as if they were in a state of unnatural tension or restraint. This probably depends on the non-homologous sides of the elementary particles having been brought into contact, a condition quite compatible with the existence of neutral and depolarizing axes, provided the non-homologous sides deviate from their proper position either 90° or 180°. In that case, polarized light, directly transmitted, will exhibit the same colours as if the sides were in the normal position. But if transmitted obliquely, the hemitropism of the combination, as we may call it, will be at once detected by the difference in colour of the two plates.

3. On the Structure and Economy of Tethea, and on an undescribed species from the Spitzbergen Seas. By Professor Goodsir.

The author, after a brief summary of the observations of Donati, M. Edwards, Forbes, Johnston, and Huxley, on various species of Tethea, described the structure, and deduced the probable economy of a large species apparently undescribed, some specimens of which he had procured from the Spitzbergen Seas.

The following peculiarities of form and structure were minutely detailed and illustrated:—

1. The turbinated form of the sponge.
2. The partial distribution of the rind.
3. The minute pores of the rind, arranged in threes; a pore in each of the angles, formed by the primary branches of the six-radiate spicula.
4. The water, instead of passing out by oscula, drains through a perforated or net-work membrane which lines a number of irregularly tortuous grooves on the surface of the attached hemisphere of the sponge,—the grooves being continuous with deep fissures, which extend into the rind, and are apparently the result of distension from internal growth.
5. The silicious spicula are arranged according to the type of the skeleton in the other Tetheæ. Elongated, slightly bent or twisted rod-like spicula, are combined in bundles by means of fibrous substance, and a few boomerang-shaped spicula, laid crossways. These bundles are arranged irregularly in the centre of the sponge, so as to form a nucleus from which radiating masses extend outwards to the rind, or beyond the surface, where the rind is deficient. The spicula of the rind are large and six-radiate. Their shafts are deeply and firmly inserted into the radiating bundles. Their three primary branches are set at angles of 120° to the shaft, and to one another. The two secondary branches at the extremity of each primary branch are long-pointed, slightly concave towards the centre of the sponge, and set at an angle of 90° to one another.
6. The fleshy mass which envelopes the spicular bundles in the interior of the sponge, consists of—1. Ordinary sponge particles; 2. Caudate particles, probably similar to the spermatozoa described and figured by Mr Huxley in an Australian Tethea; 3. Ova-like masses,

the largest of which envelope a radiating arrangement of anchor-like spicula; 4. Towards, and in the rind, elongated cellules, apparently fibrous and muscular, the fibrous connecting the spicula, and with the nucleated muscular cellules arranged transversely as figured by Donati.

7. From the structure of Tethea, as well as from the observations of Donati and M. Edwards, this group of sponges would appear to possess considerable contractility.

The following Donations to the Library were announced:—

Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. N.S. No. 40. 8vo.—*From the Society.*

Papers and Proceedings of the Royal Society of Van Diemen's Land. Vol. II., Part 1. 8vo.—*From the Society.*

The Canadian Journal; a Repertory of Industry, Science and Art, and a Record of the Proceedings of the Canadian Institute. January 1853. 4to.—*From the Institute.*

Flora Batava. 172 Aflevering. 4to.—*From the King of Holland.*

Acta Regiæ Societatis Scientiarum Upsaliensis. 3d Series. Vol. I. Fascic. 1. 4to.—*From the Society.*

Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Mathematisch-Physische Classe I. 8vo.—*From the Society.*

Ueber Musikalische Tonbestimmung und Temperatur. Von M. W. Drobisch. 8vo.—*From the Author.*

Beiträge zur Kenntnis der Gefäss-kryptogamen. Von Wilhelm Hofmeister. 8vo.—*From the Author.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1852. No. 2. 8vo.—*From the Institute.*

Memoirs of the American Academy of Arts and Sciences. N.S. Vol. IV., Part 2. 4to.—*From the Academy.*

Monday, 21*st March* 1853.

RIGHT REV. BISHOP TERROT, Vice-President, in the Chair.

The following Communication was read:—

On Circular Crystals. By Sir David Brewster K.H.,D.C.L., F.R.S., V.P.R.S.E, Associate of the Institute of France.

The author, after mentioning Mr Fox Talbot's observation, in 1836, of circular crystals from a solution of borax in phosphoric acid, stated, that about twenty years before Mr Talbot's paper was published, he had obtained circular crystals from oil of mace, and from a mixture of that oil with tallow or rosin. These circular crystals are groups of radiating prisms, in optical contact, so as to appear like individual crystals. Viewed by polarized light, they exhibit four luminous sectors, separated by a rectangular black cross, which often has its arms so divergent, as to form four dark sectors. The arms of the cross are parallel and perpendicular to the plane of primitive polarization. When a bright disc of ordinary light was looked at through these circular spots, there was seen a halo, or two halos, produced by the crystals of the oil of mace. In the case of two halos, polarized light shewed two sets of four luminous sectors, as far apart as the halos. The halos were, in fact, double, being the two images produced by the double refraction of the elementary crystals. In pursuing the inquiry, the author found that the phenomena were caused by circular crystals or groups, varying from invisibility to the $\frac{1}{200}$th or $\frac{1}{300}$th of an inch in diameter, and when of this size, exhibiting beautiful luminous sectors in polarized light. Circular crystals are easily distinguished from those which exhibit true quaquaversus polarization, by using a plate of selenite, which, with the circular crystals, produces spots or sectors of two different colours, one a little lower, the other a little higher than the tint of the selenite.

He next examined a number of substances which yield circular crystals, particularly the lithoxanthate of ammonia (a salt formed by the action of ammonia on xanthic oxide), which yields them with more facility and certainty than borax. Out of more than 300 substances, he found upwards of 70 which yielded circular crystals, about thirty

being positive, like zircon, and forty negative, like calcareous spar. The phenomena observed are most splendid, and open up a wide field of research.

The author next detailed, and illustrated with minute and carefully coloured drawings, these phenomena, as observed in the following substances, the most remarkable of the whole number.

1. *Lithoxanthate of Ammonia.*—Here, in the usual specimens, the light polarized by the sectors is the blue of the first order, often the white and the yellow of the same order. In separate circular crystals, other appearances occur. In one, the three first orders of colours appeared exactly as in the coloured rings of uniaxial crystals, proving that the elementary prisms or radii must have increased in thickness from the centre outwards, according to Newton's law of periodical colours. In others, the second and third bands were of different but uniform colours throughout, proving uniform thickness all round in each band. These colours were generally red and green, not at all related to the central tint, or to one another. In some cases, the order of colours is inverted. In the most perfect crystals, the central tints are the blue and white of the first order, in consequence of the great minuteness of the elementary crystals, which form a more uniform disc, with an exceedingly sharp black cross. This central part is surrounded by a narrow black ring, beyond which is an annulus of sectors, sometimes white, like the inner ones. This is terminated by a black circle, beyond which is a third series of sectors, either white or blue of the first order. The black cross starts into greater breadth as it passes from one annulus to the other, from the inferior degree of optical contact in the outer rings. Various other singular modifications occur in this salt, which cannot be detailed here. In some cases, there are large radiant prisms, all polarizing a golden yellow, and the black cross becomes hardly visible. In others, its divergence is so great, that the yellow sectors assume the appearance of a cross.

In some still more complex crystals, there is seen one or more narrow black rings, which arise from the absence of matter where they appear.

2. *Salicine.*—This substance yields splendid discs. When of the diameter of $\frac{1}{30}$th to $\frac{1}{8}$th of an inch, these tints are of the first and second orders, and they form objects of singular splendour. Here also, the smaller crystals polarize a bluish white. The discs of salicine

are composed of prisms varying in thickness, and, of course, in tint, and have often rims, formed of one or two concentric bands, made up of radiant bunches, proceeding from the inner margin of the bands, and not from the centre of the discs. The large discs exhibit ten, twelve, or more fine concentric lines, which are lines of cleavage. Sometimes the rim is as wide as the inclosed part, and these polarize a bluish white.

3. *Asparagine.*—This substance yields discs resembling those of salicine, but are still more brilliant and beautiful. There are some discs which exhibit no circular polarization, and others which exhibit a succession of black and white narrow rings, like those seen round the star Capella, with annular apertures.

4. *Manna.*—This gives fine negative crystals, both by fusion and solution. There is great brilliancy and uniformity of the tints, and the black cross is so sharp that its intersection is not easily seen. The discs form a united hexagonal mosaic, and have no rims.

5. *Disulphate of Mercury.*—The solution of this salt in nitric acid, gives, by slow cooling, square crystals with circular polarization, which undergo singular modifications, for which we must refer to the paper.

6. *Parmeline*, from alcohol, gives fine circular crystals.

7. *Palmic Acid*, by fusion, gives fine negative circular crystals, like the mosaic of manna.

8. *Nitrate of Uranium* gives fine negative circular crystals, from water, alcohol, ether, and oil.

9. *Palmine* gives very minute circular crystals.

10. *Chromic Acid* gives very peculiar circular crystals, composed of concentric rippled bands, generally of the blue of the first order.

11. *Berberine* gives negative circular discs, resembling those of oil of mace.

12. *Sulphuret of Cadmium*, dissolved in nitric acid, that is, nitrate of cadmium, gives beautiful negative circular crystals.

13. *Sulphate of Ammonia and Magnesia.*—This salt yields fine positive circular crystals.

14. *Hatchetine, Cacao Butter, White Wax, Tallow, Adipocire*, and all *Soaps*, and different kinds of *Fat*, give circular crystals like oil of mace.

15. *Borax in Phosphoric Acid.*—This salt yielded the circular crystals described by Mr Talbot. This salt, as well as nitrate of uranium, yields hemispherical bells, under certain circumstances, which

polarize light by refraction, and exhibit the black cross, with rings of green and red alternately. The author observed these bells to be formed of minute crystals, radiating from the apex of the bell.

16. *Mannite.*—This substance the author has found, since the paper was read, to give circular crystals more easily and certainly than any other. Those from the solution in acetic acid are the finest. The black concentric circles, indicating absence of matter, are peculiarly marked; and the sectors shade off so perfectly into the arms of the cross, as to give the discs the appearance of being formed of four solid cones. The discs are sometimes elongated into conical forms, with the black cross at the summit. A crust of opaque crystalline matter, that is, not in optical contact, often covers them, and often breaks off, shewing the circular crystal below. The cones have frequently two, three, or four black arches crossing them. In some of the largerdiscs, each successive ring is formed of radiating branches, radiating from the margin of the ring within.

17. *Oxalurate of Ammonia (pure).*—This salt, to which the author's attention was called by Professor Gregory, gives beautiful negative circular crystals, and rarely fails to yield them. With weak solutions the discs are small and exactly resemble those of the lithoxanthate of ammonia. Professor Gregory thinks that the two salts are identical, but that the lithoxanthate contains a little colouring matter. With strong solutions, the salt yields discs often nearly opaque, but surrounded by concentric rings of marginal radiations, of different tints. In some large crystals, the central circle consists of green of the second order, with a faint black cross, descending to the white of the first order; the next ring, which is separated by a narrow black band from the first, exhibits the white, which rises to the yellow of the second order, and again descends to the white of the first, completing the second ring. Three similar rings follow in succession, and each of the five has a uniform tint throughout its circumference, proving a uniform thickness in each band. These crystals, when a number are seen in the dark field, are singularly beautiful. This salt yields cones like those of mannite, and these have, in the centre of the black cross, a second cross bisecting the luminous sectors.

18. *Hippuric Acid* gives fine circular crystals with alcohol. In these, the radial lines are often divided by black spaces as broad as the luminous lines; and the whole disc is covered with numerous minute concentric circles, at equal distances from one another. In

some cases, the discs consist of eight or ten sectors of uniform thickness, which become black in the plane of primitive polarization.

The following is the author's list of substances giving circular crystals.

1. *Positive Circular Crystals.*

Sulphate of ammonia and magnesia.
... ammonia and cobalt.
... ammonia and iron.
... ammonia and manganese.
... potash and zinc.
... red oxide of manganese.
Disulphate of mercury.
Hydrate of potash.
Citrate of potash.
Muriate of morphia.
... magnesia.
Muriate of strontia.
Almond soap.
Starch.
Substance in garnet.
... mica.
Mannite.
Citrate of ammonia.
Myristic acid.
Cupreo-sulphate of potash.
Kreatinine.

2. *Negative Circular Crystals.*

Borax in phosphoric acid.
Lithoxanthate of ammonia.
Oxalurate of ammonia, pure.
Kreatine.
Salicine.
Asparagine.
Manna.
Parmeline.
Palmine.
Palmic acid.
Esculine.
Berberine.
Cinchonine.
Theine.
Thionurate of ammonia.
Carbazotate of potash.
Hippuric acid.
Sulphate of copper and iron.
... ... and zinc.
... magnesia and potash.
... copper and ammonia.
... zinc and ammonia.
... zinc.
Substance in garnet.
Stearine.
Stearic acid.
Palmitic acid.
Oil of mace.
Animal fat.
Cacao butter.
Hatchetine.
White wax.
Chrysoleptinic acid.
Succinate of zinc.
Chromic acid.
Citric acid.
Nitrate of uranium.
... urea.
... brucine.
... strychnine.
Gallic acid.
Sulphuret (nitrate) of cadmium.
Sulphuret of potassium.
Santonine.
Acetate of strontia.
... quinine.
Chloride of zinc.
Oxide of uranium.
Protoxide of nickel.
Phosphate of nickel.
Carbonate of nickel.
Substance in mica.
Adipocere.
Margaric acid.
Ethal.

The following substances also exhibit circular polarization, and the structure is, in all cases but one, negative.

Hoof of the horse, vertical and transverse sections.
Hoof of an ass, transverse section.
Transparent aperture in the wing of a beetle.
Hoof of rhinoceros.
Horn of rhinoceros, transverse and vertical sections.
Horn of antelope.
Sections of hairs of animals.

In conclusion, the author offered some observations on the formation and destruction of these discs. He regarded them as abnormal crystallizations, in which the particles are in unstable equilibrium, and have a constant tendency to arrange themselves according to their natural polarities. Hence, circular crystallizations are apt, after a longer or shorter time, to disappear, the particles either dissolving, or assuming the form of ordinary crystals, lying in all directions, or accumulated in radial or circular lines. In oil of mace, the decomposition is effected in a night; in mannite, not for several years.

The observations recorded in this paper, have occupied the author during the last ten years, and must have an important bearing on many unsettled questions in molecular philosophy.

The following Donations to the Library were announced :—

Ordnance Survey. Astronomical Observations made with Airy's Zenith Sector, from 1842 to 1850, for the determination of the Latitudes of various Trigonometrical Stations used in the Ordnance Survey of the British Isles. By Captain W. Yolland. 4to.—*From the Hon. Board of Ordnance.*

Archives du Muséum d'Histoire Naturelle, publiées par les Professeurs-Administrateurs de cet Etablissement. Tome VI., Liv. 3 & 4. 4to.—*From the Editors.*

The American Journal of Science and Arts. 2d Series. No. 43. 8vo.—*From the Editors.*

Monday, 4*th April* 1853.

SIR T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read:—

1. On Nitric Acid as a source of the Nitrogen found in Plants. By Dr George Wilson.

The author, after referring to the opinions of those who contend that plants derive their nitrogen only from ammonia, shewed, in justification of the belief, that they also derive that element from nitric acid:—

Firstly, That nitrates are largely offered to plants, both as they grow wild, and as they are artificially cultivated.

Secondly, That plants do not refuse the nitrates thus offered to them.

Thirdly, That the nitrates which enter plants do not, if properly diluted, do injury to any class of them.

Fourthly, That nitrates largely promote the growth of the most important plants.

Fifthly, That as chemists are at one in regarding the chief function of a plant, considered as a piece of chemical apparatus, to be the deoxidation of those oxides, such as water, carbonic acid, and sulphuric acid, which enter it, they cannot with any consistency deny that nitric acid, which is one of the most easily deoxidised of all oxides, must, more easily than the oxides referred to, part with its oxygen, and give up nitrogen to the plant.

Sixthly, That although it would be unwise to be dogmatic on the phenomena which occur within the recesses of a plant, or to affirm that it cannot derive nitrogen from many sources; yet, according to the present conclusions of science, it may be reasonably urged, that the simplest chemical expression which we can give to our belief regarding the source of the nitrogen which is so important to plants, must be, that the inorganic or mineral representative and parent of all the nitrogenous constituents of plants, and through them of animals, is neither ammonia alone, nor nitric acid alone, but the compound of both, *i. e.*, nitrate of ammonia.

2. Observations on the Amount, Increase, and Distribution of Crime in Scotland. By George Makgill, Esq. of Kemback.

The author read some "Observations on the Amount, Increase, and Distribution of Crime in Scotland," being the results of an analysis of the Official Tables of criminal offenders for the ten years ending 1850, and of the Prison Board Returns, compared with various statistical data.

The criminal tables of Scotland confirm, in many important particulars, the observations of M. Guerry, M. Quetelet, and Mr Joseph Fletcher, as to the causes of the occasional fluctuations in the amount of crime, the chief of which appear to be—1*st*, Scarcity of the chief articles of subsistence; 2*d*, Disturbances of commercial credit, and of the labour market; 3*d*, Political excitement.

Among the other results of the author's inquiry are the following:—

1. The ratio of crime to population is apparently one-tenth higher in England than in Scotland; but,—

2. In England this ratio has for many years been gradually diminishing, while in Scotland it is rapidly and steadily increasing.

3. This increase shews itself chiefly in crimes accompanied by violence, which in Scotland constitute 40 per cent. of the total offences recorded, while in England they are only 14 per cent.

4. This excess and increase are chiefly remarkable in the agricultural, pastoral, and thinly-peopled districts of the Border, where aggravated crimes against the person are greatly more common in proportion to population, than in the densely-crowded manufacturing counties of the west. In Berwick and Roxburgh, crime of all kinds has increased more rapidly in the last ten years, than in any other part of the country; while in Lanarkshire the augmentation has been trifling, and in Renfrew the number has actually diminished. An analogous fact has been observed in regard to England.

5. Looking, however, not to the ratio of *increase*, but to the *absolute amount* of crime in proportion to population, the highest counties are still those in which mining industry is found in conjunction with factory labour, with the exception of Ayr and Fifeshire.

6. There does not appear to be any marked coincidence between the excess of crime and that of pauperism.

7. The counties in which the number of licensed spirit-shops is greatest in proportion to population, are all distinguished for the frequency of crime; while those in which they are fewest are, with a single exception, greatly below the average of crime.

8. Excess in the proportion of real property to population is, in general, accompanied by excess of crime.

9. Eight out of the ten counties which stand highest in the list of serious crime, exhibit a proportion of school attendance considerably above the average of the country; while of the counties in which crime is *rarest*, all but two are greatly below the general educational standard.

10. The per-centage of female criminals is much larger in Scotland than in any European country of which the records are published. In France, the number of females in each 100 culprits is 15; in England, 19; and in Scotland, 28.

11. A marked decrease in the number of juvenile offenders in the large towns has been going on for the last six or seven years.

12. There is a remarkable uniformity from year to year in the *results* of criminal proceedings; the proportion of convictions to trials never having varied in the last four years more than one per cent.

13. The number of sentences under the aggravation of previous conviction has been steadily and rapidly increasing for the last fifteen years; indicating either greater efficiency of the police, or insufficiency in the character of punishment.

14. In the last half of the ten years under review, the number of cases in which *insanity* has been successfully pleaded in bar of trial, is more than double what it was in the first half; and the number of accused who have been found insane *on* trial, has multiplied nearly to the same extent.

The author concluded by regretting that the deficiency of statistical materials in Scotland, and in particular the total want of a system of registration, prevented the extension of the inquiry to many subjects of great public interest.

Monday, 18*th April* 1853.

JOHN CAY, Esq., Advocate, in the Chair.

The following Communications were read:—

1. Notice of recent Measures of the Ring of Saturn. By Professor C. Piazzi Smyth.

This communication chiefly described the observations made by W. S. Jacob, Esq., of the Madras Observatory, during the last apparition of the planet, with a telescope having a six-inch object-glass, lately completed by Lerebours and Secretan.

Previous to its being sent to India, the object-glass had been tested at the Edinburgh Observatory; and its quality, which was then approved, had been more conspicuously brought out in the subsequent trial in a clearer climate.

Immediately after the receipt of the object-glass, in September 1852, Mr Jacob directed it to Saturn, then in the zenith, and immediately perceived the "transparency" of the dark ring which has since been discovered independently by Mr Lassel and others; and on very accurately adjusting the focus, he saw a fine division in the outer dark ring. This appears to have escaped all other observers at the same time, except perhaps Mr Dawes, who had some suspicions of such a phenomenon. But Mr Jacob saw it clearly for all the rest of the apparition of the planet, could trace it through more than half the circumference of the ring, and was enabled to get good measures of it with the wire micrometer.

Such a fine division of the outer ring has not unfrequently been suspected before, and even seen, but only on one or two special nights, by each observer, and then merely through a very small part of the circumference at the ansæ.

Mr Jacob's observations, therefore, establish the fact permanently among the phenomena of the planet's appearance, and lead us to expect more still from him, when, as will be the case in a few years, the ring of Saturn is presented to our view at its maximum angle of inclination.

The author then concluded with an account of the most probable theory with regard to the material and economy of the rings, which he conceived to be fluid and vaporous, and indicating, with

a certain variation, due, perhaps, to a magnetic or diamagnetic condition, the appearance of the earth in what Mr Nasmyth calls its "pre-oceanic" state; when, still incandescent, the ocean could find no resting-place on its surface, but would have been compelled to form a dense vapour envelope in the atmosphere; of frozen particles outside, by reason of the coldness of space, and of watery vapour inside, from the radiation of heat from the hot internal globe.

2. Chemical Notices. By Professor Gregory.

1. *On the new compounds of Còbalt described by Frémy and others.*

Claudet in London, and Genth in Germany, about the same time observed a new compound of cobalt, with the elements of ammonia and chlorine. Frémy, about the same time, announced a far more extended investigation, the result of which was the discovery of no less than five series of salts, in some of which the base, with oxygen acids, was formed of oxides of cobalt along with more or less ammonia, and, with hydrogen acids, was formed of cobalt with more or less ammonia. In other series, salts of oxides of cobalt, for the most part previously unknown oxides of this metal, seem to have combined with more or less ammonia. I shall not enter farther into any details of the views of Frémy, in regard to many of these salts, which are very complicated, and confessedly provisional. But I have made some experiments on the formation and analysis of two of the most remarkable of the salts described by him, one of which belongs to the series of Roseocobaltiak, the other to that of Luteocobaltiak. Both are chlorides or hydrochlorates, and the former, or the pink salt, is the same as was described by Claudet and Genth. I find that both this and the other—which is yellow, a very unexpected fact in compounds of cobalt—may easily be obtained by dissolving protochloride of cobalt in water, adding sal-ammoniac and an excess of ammonia, and passing chlorine through the solution, till the chlorine is in excess. It then deposits a mixed mass of pink and yellow salt, which may be separated by the greater solubility of the yellow salt in water very slightly acidulated with hydrochloric acid, in which the pink salt is almost insoluble. The yellow salt may be obtained in large and fine crystals by spontaneous evaporation. When large, the crystals are of a deep orange-red, but the powder and the small crystals are bright orange-yellow. The red salt is sparingly soluble in hot water, which, on cooling, deposits it in dark red crys-

tals of small size. It is generally obtained, however, as a crystalline powder of a fine pink colour, as it is usually rapidly formed, and deposited too quickly to form regular crystals.

The chemists who have analysed the red or pink salt are not agreed as to its composition, for while Claudet found it to contain no oxygen and no water, Frémy admits 1 eq. of water, and Genth considers it as a compound of sesquioxide of cobalt, ammonia, and chlorine. I have made a number of analyses of this salt, prepared in different ways, and when it has been slowly ignited in a current of hydrogen, to determine the cobalt which is left in the metallic state, I have not in any case obtained a trace of water. Consequently the salt cannot have the formula given to it by either Genth or Frémy. As that of Genth is absolutely erroneous, I shall give here the empirical formulæ of Frémy and Claudet, with my own results.

Claudet, ...	$Co_2\,Cl_3\,N_5\,H_{16}$
Frémy, ...	$Co_2\,Cl_3\,N_5\,H_{16}\,O$
Gregory, . . .	$Co_2\,Cl_3\,N_5\,H_{15}$

	Claudet.		Frémy.		Gregory.	
	Theory.	Experiment.	Theory.	Experiment.	Theory.	Experiment.
Co	23·16	23·50	22·8	22·6	23·55	23·79
Cl	42·34	42·38	41·0	40·9	42·51	42·86
N	27·83	27·79	27·0	26·2	27·94	28·00
H	6·36	6·34	6·1	6·4	5·98	6·00
O	...	...	3·1	3·1	...	...

It is very difficult to form any distinct idea of the rational formula, whichever empirical one we adopt. The most interesting point is this, that from this compound analogous ones with oxygen acids may be formed, and that from these, by the action of alkalies, a base may be separated, although it has not yet been isolated in a state of purity, which appears to consist of ammonia *plus* some oxide of cobalt. If such bases exist, they will probably, like other oxidised bases, yield, with hydrochloric acid, water and chlorides, and thus our red salt would be the chloride of the radical, which, with oxygen, forms the base in the oxidised salts. But we must not dwell on possibilities; and my object is to shew, first, that the red compound does not, as Frémy states, contain oxygen (at least that which I have examined), and that before we can speak with confidence as to its true formula, we must have more certainty as to the empirical one.

With regard to the yellow salt, this, according to Frémy, contains

no oxygen, and 1 eq. of ammonia more than the red salt. My results lead to the same conclusion, so that its empirical formula appears to be $Co_2\,Cl_3\,N_6\,H_{18}$, or $Co_2\,Cl_3 + 6\,NH_3$. It also forms salts with oxygen acids, and from these an oxidised base may be separated, but has not been fully studied.

All the three authors who have preceded me describe the crystals of the red salt as regular octohedrons, and they must be very nearly so; but Sir D. Brewster informs me that they do act to a small extent on polarized light, in which case they cannot belong to the regular system.

Frémy, differing from Genth, also describes the yellow salt as forming regular octohedrons. But this is, I think, a mistake; for, as far as I have examined them, they appear to be prismatic. Genth describes the crystals as rhombic or klino-rhombic.

2. *On the Acid formed when Potash acts on Oil of Bitter Almonds.*

When commercial oil of bitter almonds is mixed with an excess of an alcoholic solution of potash, there is formed, instead of benzoine, a salt, crystallising in scales, which are very soluble in alcohol. This salt is said in books to be benzoate of potash. And when decomposed by acids, it yields an acid which, to all appearance, is benzoic acid. But it is worthy of notice, that if we form benzoate of potash with common benzoic acid, the salt is hardly at all soluble in hot alcohol, and does not crystallise in the same way as the salt above mentioned; indeed can hardly be got to crystallise at all. I have made many experiments to ascertain the cause of this strange difference, but I have as yet been unable to detect it. The salt I exhibit has been three times recrystallised from alcohol, and is as soluble as ever; while yet the acid extracted from it appears identical with benzoic acid. Its analysis, indeed, does not perfectly agree with that of benzoic acid, but the difference is so slight, as not to affect the formula.

Is it possible that the presence of some foreign matter communicates to the potash salt the property of solubility in alcohol, and that of crystallising readily? But if so, the more it is purified, the less soluble it should become. This I have not found to be the case. I rather suspect that the acid is not truly benzoic acid, and that a more minute investigation will detect its true nature. Its resemblance to benzoic acid is certainly very striking, but we know that homologous compounds, although different in composition, often resemble each other in as great a degree.

3. *On a spontaneous Metamorphosis of Alloxan.*

I have found that alloxan forms two kinds of hydrated crystals. Those, with six eqs. of water, are large, regular, transparent, and do not readily effloresce in the air, nor undergo any change when kept. But there is another form much more frequent, which, according to my analysis, contains seven or possibly eight eqs. of water. It forms large but irregular masses, with their sides graduated like steps, and effloresces on exposure to the air very readily. I rather think this kind forms in solutions which are slightly acid from free nitric acid, which is likely to be the case in preparing alloxan. When placed in stoppered bottles, and exposed to the natural changes of temperature in summer, these crystals became partially liquified, and after a year or two I found the contents of several bottles entirely changed. A very large part had become nearly insoluble in cold water, and the solution filtered from this part deposited, on evaporation, *first*, small colourless crystals; *secondly*, a crystalline and yellowish mass; and, last of all, the little remaining liquid dried up into a tough semi-crystalline mass, which became pink on exposure to the air of the laboratory.

I find the insoluble, or sparingly soluble matter, to be pure alloxantine. The next crystals are quite distinct, both in form and properties, and the following portions exhibit also characters of their own. No alloxan has appeared. But since the difference between alloxan and alloxantine is simply that the latter contains one eq. of hydrogen more than the former, then the other substances must either contain less hydrogen than alloxan, or, if the hydrogen has been derived from water, they must contain more oxygen. I regard the latter as the probable case, and I rather think that the new product or products are of an acid nature. But I have not yet been able to obtain them pure; and if I had, the difference in composition is so small, that analysis will hardly suffice to make sure of it. We must therefore have recourse to the difference of properties, and here all that I have as yet been able to do is to ascertain that besides alloxantine, at least one, but probably two substances have been formed, different both from alloxan and from alloxantine, as well as from all the allied compounds with which I am acquainted; and that one if not both of these are acid compounds. The investigation is one of very great difficulty, from the tendency of all these compounds to be altered by contact with other substances, or by heat, and from the great similarity in the properties of many of them.

One useful hint which the chemist may derive from these observations is, that if he wishes to preserve alloxan, it ought to be got in the anhydrous form, which is done by evaporating its solution at 140° or 150°, when anhydrous crystals alone are deposited in the warm solution, which is poured off and further evaporated, as long as it yields crystals. It is apt to be decomposed at higher temperatures.

3. Observations on the Structural Character of Rocks. Part II. By Dr Fleming.

In proceeding to consider still farther the physiology of rocks, the author proposed in this communication to confine himself to the illustration of

1. *The Columnar Structure.*—After enumerating examples of this structure, as occurring in the neighbourhood of Edinburgh, in cannel coal, sandstone, clay, ironstone, clinkstone, claystone, greenstone, and basalt, he exhibited examples of similar appearances in oven soles and fragments of the walls of vitrified forts. The ordinary explanation of this structure as the result of cooling from a state of fusion he pointed out as unsatisfactory, even in the case of basaltic pillars, and inapplicable to similar appearances as occurring in sedimentary rocks. He considered the whole phenomena explicable as connected with one cause, viz., shrinkage, arising from the escape of aqueous or volatile matter.

2. *The Cone in Cone Structure.*—Examples of this structure occur in impure ferruginous limestone at Joppa, the Water of Leith, and other places, in connection with the coal measures. The author referred the origin of this structure to shrinkage, conjoined with a certain amount of molecular aggregation, or crystallising influence.

4. Some Observations on Fish, in relation to Diet. By Dr John Davy.

In this communication the attention of the author is chiefly directed to two subjects of inquiry :—

1*st*, The comparative nutritive power of fish, taking the specific gravity of their substance, and the proportion of solid matter left on thorough drying, as a measure of the same. In illustration, two tables are given, containing the results of trials on several kinds of fish and other articles of animal food; from which he deduces that

the difference of nutritive power of these several articles, has commonly been overrated.

2dly, The peculiar qualities of fish, if any, as articles of diet. On this head, excusing himself from entering into details from want of sufficient data, he expresses the opinion that fish, as diet, are not without specific power, conducive to health, and the prevention of certain diseases, especially scrofula, pulmonary consumption, and goître. He founds this opinion partly on experience,—the absence or comparative rarenesss of these diseases amongst people using such a diet; and partly on the circumstance, that iodine in minute quantity enters into the composition of sea-fish, having found traces of it in every instance of these fish in which he has specially sought for it; an opinion, moreover, he thinks strengthened by the fact, that the same element, iodine, exists in cod-liver oil, which has proved so serviceable, if not in curing, at least in mitigating pulmonary consumption.

The following Gentleman was duly elected an Ordinary Fellow:—

Hugh Scott, Esq. of Gala.

The following Donations to the Library were announced:—

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1852–3. 4to.—*From the French Government.*

Memorie della Accademia delle Scienze dell' Instituto di Bologna. Tom. II. 4to.—*From the Academy.*

Rendendrionto delle Aduvanze e de' Lavori della Reale Accademia delle Scienze sezione della Societa Reale Borbonica. N.S. Nos. 1–5. 4to.

Relazione Lalla Malattia della Vite apparsa nei contorni di Napoli ed altri luoghi della Provincia fatta da una commissione della Reale Accademia delle Scienze. 4to.—*From the Academy.*

Opuscula Matematici di Tito gonella. 4to.—*From C. Babbage, Esq.*

The Assurance Magazine, and Journal of the Institute of Actuaries. No. 11. 8vo.—*From the Institute.*

Catalogue of a Collection of Ancient and Mediæval Rings and Personal Ornaments formed for Lady Londesborough. 4to.—*From Lord Londesborough.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1853–54. No. 44.

Seventy-First Session.

Monday, 5th December 1853.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read :—

1. Remarks on the Torbanehill Mineral. By Dr Traill.

The Torbanehill mineral is so very peculiar that I cannot call it either a bituminous shale or a coal, to both of which it has a considerable resemblance.

After comparing it carefully with a great variety of English and Scottish coals, and with many varieties of bituminous shale, I conclude that it is a mineral hitherto undescribed by systematic mineralogists, and propose for it the name of Bitumenite.

It appears to me to have been formed by the impregnation or injection of shale with liquid bitumen. Its colour is blackish-brown. Its specific gravity = 1·284.

I compared it carefully with several specimens of English *cannel* and common coal, and with thirteen varieties of Scottish *parrot* or cannel coal, and other coals of this kingdom, from all of which it differed much in mineralogical characters.

1. When its thin edges are examined by a strong light, or when very thin slices are inspected in the usual way, it is translucent, transmitting a reddish-brown light, whereas coal is opaque on the thinnest edges.

2. Its fracture, though conchoidal, is perfectly dull in every direction.

3. Its streak is not shining, but quite dull.

4. It changes colour strongly in the streak, which exhibits a distinct pale ochre yellow.

5. It breaks with some difficulty, especially in the cross fracture, and exhibits some degree of elasticity. It is, therefore, not brittle.

6. It ignites very readily, and gives out much light; but when this expires, as it soon does, the remaining mass with great difficulty affords the redness of ignition, as observed in coal under similar circumstances; and it retains its form, though it becomes white by incineration.

It consists of volatile matter from 72·5 to 84·1 per cent.
White solid residue, 27·5 to 15·9 ...

It affords a large quantity of fine combustible gas, and also, on distillation, yields much *paraffine*.

It occurs in a bed in the coal formation, associated with shale and ironstone, in the county of Linlithgow, near Bathgate.

The Central Board of Customs of the German Zollverein, assisted by the principal mineralogists of Berlin, have, since this paper was written, decided that the Linlithgowshire mineral is not a coal, and may be imported duty-free, which coal is not.

2. Notice of the Blind Animals which inhabit the Mammoth Cave of Kentucky. By James Wilson, Esq.

The author commenced with a general sketch of the natural character and condition of the great cave, as it is the peculiarities of their local position which constitute the most remarkable feature in the history of the animals by which it is inhabited. The cave descends through the uppermost rocks of the "Barrens" to those which are nearly or quite upon a level with the Ohio. Though called a cave, it is in fact a series of underground gallerie
ing from and inosculating with each other in various di

total length of windings being almost incalculable, and even the direct distance from the entrance to the termination extending many miles. The temperature of these inland galleries is uniformly 59° of Fahrenheit all the year round; and a current of air is very perceptible near the mouth, proceeding outwards or inwards according as the temperature of the external air is greater or less than that of the subterranean region. The air within is uniformly pure, even exhilarating; and this is attributed in a large measure to the great beds of nitre which disengage oxygen during the formation of nitrate of lime. The general boundaries of the caverns are of limestone.

Of the mammiferous animals described as inhabitants of these caverns, there are two species of bat and one species of rat, the latter being confined to, and characteristic of, the locality. If not blind, its organs of vision are very defective.

Two species of fish were noticed, of one of which, *Amblyopsis spelæus* of Dekay, specimens were exhibited. It is totally blind, possessing not even rudimentary organs of sight, dissection having shewn that the optic nerve, and other essential parts, are wanting.

Of the crustaceous tribes a blind cray-fish, *Astacus pellucidus* of Tellkampf, was exhibited. The peduncle of the eye exists, but the actual organ of sight is absent. The observance of this eyeless peduncle had misled some observers into the belief that the creature was not blind.

Various kinds of arachnides, of true insects, and of animalcular species, the majority of them quite blind, were then noticed in the order of their position in systematic arrangements.

The author concluded by referring to the difficulties which beset the theoretic question, as to whether these creatures were blind from their creation, or whether certain species, originally endowed with sight, had wandered by some mischance into those darksome depths, and in the course of ages had lost the organs of a sense, the functions of which they could no longer exercise.

The following Gentleman was duly elected an Ordinary Fellow:—

Græme Reid Mercer, Esq., Ceylon Civil Service.

The following Donations to the Library were announced:—

Memoirs of the Royal Astronomical Society. Vol. XXI., Parts & 2. 4to.—*From the Society*.

Proceedings of the American Association for the Advancement of Science. Sixth Meeting, held at Albany (N. Y.) August 1851. 8vo.—*From the Association.*

Abhandlungen der Königlichen Gesellschaft der Wissenschaften zu Göttingen. V. Band. für 1851 & 1852. 4to.—*From the Society.*

Mémoires de l'Academie des Sciences de l'Institut de France. Tome XXIII. 4to.—*From the Institute.*

Abhandlungen der Philosoph.-Philologischen Classe der Königlich Bayerischen Akademie der Wissenschaften. Band XVII., 1ste Abtheil. 4to.—*From the Academy.*

Nouveaux Mémoires de la Société Helvétique des Sciences Naturelles. Tome XII. 4to.

Mittheilungen der Naturforschen Gesellschaft in Bern. 1851. Nr 195–257. 8vo.

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft bei ihrer 36sten versammlung in Glarus. 1851. 8vo.—*From the Society.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bde 4 & 5. 4to.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bde 9 & 10. 8vo. —*From the Academy.*

Abhandlungen der Kaiserlich Geologischen Reichsanstalt. Band. I. 1852. Fol.—*From the Institute.*

Astronomical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1851. 4to.—*From the Royal Society.*

The Assurance Magazine and Journal of the Institute of Actuaries. Nos. 12 & 13. 8vo.—*From the Institute.*

Journal of the Asiatic Society of Bengal. Edited by the Secretaries. Nos. 230-234. 8vo.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. V., Part 3. 8vo. —*From the Society.*

Journal of the Horticultural Society of London. Vol. VIII., Parts 2 & 3. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. VI., Parts 1, 2, & 3. 8vo.—*From the Society.*

The Quarterly Journal of the Geological Society. Vol. IX., Parts 2 & 3. 8vo.—*From the Society.*

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XV., Part 1. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. No. 41 (N. S.) 8vo. —*From the Society.*

The Twentieth Annual Report of the Royal Cornwall Polytechnic Society. 1852. 8vo.—*From the Society.*

The American Journal of Science and Arts. Nos. 44, 45, & 46. 8vo.—*From the Editors.*

Transactions of the Pathological Society of London. Vol. IV. 8vo. —*From the Society.*

Memoirs of the Literary and Philosophical Society of Manchester. 2d Series. Vol. X. 8vo.—*From the Society.*

Catalogue of the Birds in the Museum of the Asiatic Society of Bengal. By Edward Blyth. 8vo.—*From the Society.*

Transactions of the American Philosophical Society, held at Philadelphia, for promoting Useful Knowledge. (N. S.) Vol. X., Part 2. 4to.—*From the Society.*

Observations made at the Magnetical and Meteorological Observatory at Hobart Town, in Van Diemen Island. Printed by order of Her Majesty's Government, under the superintendence of Colonel Edward Sabine. Vol. III. 4to.

Observations made at the Magnetical and Meteorological Observatory at Toronto, in Canada. Printed by order of Her Majesty's Government, under the superintendence of Colonel Edward Sabine. Vol. II. 4to.—*From Her Majesty's Government.*

Observations made at the Magnetical and Meteorological Observatory at Bombay. Printed by order of the Honourable East India Company, under the superintendence of Arthur Bedford Orlebar, M.A. 1845, 1846, 1847, & 1848. 4to.—*From the Hon. East India Company.*

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. 1852. 4to.

Monatsbericht der Königl. Preuss. Akademie der Wissenschaften zu Berlin. November 1852—Juli 1853. 8vo.—*From the Society.*

Monday, 19th December 1853.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read:—

1. Additional observations on the Diatomaceous Earth of Mull, with a notice of several new species occurring in it, and Remarks on the value of Generic and Specific Characters in the Classification of the Diatomaceæ. By William Gregory, M.D., Professor of Chemistry.

The author, after mentioning his previous communications on this subject, stated, that continued investigations of the deposit had yielded the extraordinary number of about 150 species of Diatomaceæ, and that as several of these had been only recently observed, it was nearly certain that more yet remained.

Of these species, from 12 to 15 appear to be undescribed, and there are also 7 or 8 new to Britain, or not hitherto admitted as British species.

The following list contains the names of 118 known and described species occurring in the Mull deposit:—

List of admitted British Species of Diatomaceæ found in the Mull Deposit up to 30th November 1853.

1. Epithemia turgida.
2. „ Zebra.
3. „ argus.
4. „ ocellata.
5. „ alpestris.
6. „ ventricosa.
7. „ gibba.
8. Eunotia gracilis.
9. „ triodon.
10. „ tetraodon.
11. „ Diadema.
12. Cymbella Ehrenbergii.
13. „ cuspidata.
14. „ affinis.
15. „ maculata.
16. „ Helvetica.
17. „ Scotica.
18. Amphora ovalis.
19. Cocconeis Placentula.
20. „ flexella (Thwaitesii).
21. Coscinodiscus excentricus.
22. Cyclotella Kützingiana.
23. „ antiqua.
24. „ Rotula.
25. Surirella biseriata.
26. „ linearis.
27. „ splendida.
28. „ nobilis.
29. „ Craticula.
30. „ Brightwellii.
31. „ minuta.
32. „ ovata.
33. Tryblionella marginata.
34. „ augusta.
35. Cymatopleura spiculata.
36. „ Solea.
37. „ elliptica.
38. Nitzschia sigmoidea.
39. „ linearis.
40. „ sigma.
41. „ amphioxys.
42. „ minutissima.

43. Navicula rhomboides.
44. „ serians.
45. „ affinis.
46. „ dicephala.
47. „ firma.
48. „ ovalis.
49. „ obtusa.
50. „ Semen.
51. „ gibberula.
52. „ angustata.
53. „ pusilla.
54. „ tumida.
55. „ inflata.
56. „ crassinervia.
57. Pinnularia major.
58. „ viridis.
59. „ acuminata.
60. „ nobilis.
61. „ cardinalis
62. „ oblonga.
63. „ divergens.
64. „ acuta.
65. „ gibba.
66. „ Tabellaria.
67. „ lata.
68. „ alpina.
69. „ mesolepta.
70. „ interrupta.
71. „ radiosa.
72. „ gracilis.
73. „ viridula.
74. „ stauroneiformis.
75. Stauroneis Phœnicenteron.
76. „ gracilis.
77. „ anceps.
78. „ linearis.
79. „ dilatata.
80. „ acuta.
81. Pleurosigma attenuatum.
82. Synedra biceps.
83. „ radians.
84. „ fasciculata.
85. „ ulna.
86. „ capitata.
87. „ delicatissima.
88. „ Vaucheriæ ?
89. Cocconema lanceolatum.
90. „ cymbiforme.
91. „ Cistula.
92. „ parvum.
93. Gomphenema coronatum.
94. „ constrictum.
95. „ capitatum.
96. „ dichotomum.
97. „ acuminatum.
98. „ Vibrio.
99. „ tenellum.
100. Himantidium majus.
101. „ Arcus.
102. „ bidens.
103. „ gracile.
104. „ pectinale.
105. „ undulatum.
106. Fragillaria capucina.
107. Odontidium Tabellaria.
108. Denticula tenuis.
109. Tetracyclus lacustris.
110. Tabellaria fenestrata.
111. „ ventricosa.
112. „ flocculosa.
113. Melosira varians.
114. „ arenaria.
115. Orthosira nivalis.
116. „ aurichalcea.
117. Collatonema vulgare.
118. Diatoma vulgare.

The following are new to Britain, or now first distinguished from others :—

1. Epithemia gibberula.
2. Eunotia bigibba, *Kütz.*
3. „ Camelus, *Kütz.*
4. „ depressa, *Kütz.*
5. Navicula lævissima.
6. „ Trochus.
7. Cocconema gibbum.
8. Himantidium exiguum, *Bréb.*

Of these 8 species, figures were exhibited ; and in the case of Eunotia bigibba a number of striking varieties were figured, and compared with several varieties of Himantidium bidens, with which it had hitherto been confounded.

The author then proceeded to describe and illustrate by figures the following species, most of which are new to science :—

1. Eunotia incisa, *n. sp.* with 2 varieties.
2. Pinnularia latestriata, *n. sp.* 2 varieties.
3. Cymbella , *n. sp.*
4. Gomphonema Brebissonii, *n. sp.?*
5. „ hebridense, *n. sp.*
6. Stauroneis rectangularis, *n. sp.*
7. Pinnularia exigua, *n. sp.?*
8. „ undulata, *n. sp.*
9. „ parva, *n. sp.?*
10. „ tenuis, *n. sp.*
11. Tryblionella augustata? 3 varieties of this known species, if not of a new one.
12. Navicula spiculata, *n. sp.* Discovered by the Rev. W. Smith, in the living state at Grasmere, but not yet described. The author also found it in the Mull deposit.
13. Pinnularia divergens? Several very remarkable varieties which the author referred, with some doubt, to this species, lately established by Mr Smith.

Having thus described about 140 species in the above three categories, the author stated, that some additional forms, not yet precisely determined, would have to be added to each; and he next proceeded to make some general remarks on the value of generic and specific characters in the Diatomaceæ.

He showed that some genera had been established on apparently insufficient grounds; thus, Eunotia is separated from Himantidium, because the latter occurs in chains, the former solitary. But Eunotia tetraodon is found in chains, both alive and in this deposit; and if we transfer it to Himantidium, we separate it from Eunotia Diadema, to which it is so closely allied. The author concluded that these two genera should be united.

Again, Cocconema is separated from Cymbella by the former having a stipes, the latter not. But this seems a very slight foundation for a genus where the frustules cannot otherwise be distinguished, as in this case; and here also the author would unite the two genera.

In regard to specific characters, the author showed that those usually resorted to, such as form, size, number, and arrangement of striæ, &c., are subject, in certain species, to almost unlimited variation, of which he gave a striking example in Eunotia triodon, and others in Pinnularia divergens, Eunotia bigibba, and Himantidium bidens. In other cases, again, the species never varies except to a small degree in size. This was shown in Eunotia tetraodon and E. Diadema, and mentioned as occurring in Epithemia gibba, Navicula serians, Amphora ovalis, Pinnularia alpina, P. lata, and many others. It therefore appears that the tendency in a species to vary may be regarded as itself a specific character, as may also the absence of this tendency.

With regard to the actually admitted genera and species, the

author expressed the opinion, that so long as new forms are daily discovered (and that this is the case he proved by many recent examples), we are liable to err in establishing both genera and species. He therefore recommended the collection and figuring of all such forms as appear distinct, to which, of course, provisional names must be given, with a view to the future employment of these materials, when new forms shall have become rare, in ascertaining the true natural groups, whether generic or specific.

The author took occasion, from the occurrence of the permanence of characters above alluded to in many species, to combat the view of Professor Kützing, according to whom, species, as natural groups, do not exist.

Finally, he stated, that the remaining forms would be described in a future communication.

2. On the Physical Appearance of the Comet 3, of 1853. By Prof. C. Piazzi Smyth.

Referring to the general descriptions which had been published in scientific journals and elsewhere of the appearance of this comet, the author pointed out,—1*st*, That the colour which had been attributed to it was merely the adventitious tint due to the twilight atmosphere through which it was seen. 2*dly*, That what had been described as the nucleus of the comet, and of so many thousand miles in diameter, nine days before the perihelion passage, was merely the head, composed of the same light, vaporous transparent matter as the tail; and subject to the same remarkable compression and condensation on approaching the sun.

This condensation had not been sufficiently attended to by cometary observers; but, nevertheless, rendered it absolutely necessary, in giving the size of any comet, to state at what part of its orbit the body might be at the time. The now well recognized fact of such condensation, combined, of course, with the stronger illumination of the sun at a less distance, also gave the best, if not the only, sufficient explanation of the remarkable increase in brightness of some comets about the time of their perihelia.

Moreover, the accurate observation of the amount of such condensation, depending as it does mainly on the proportion between the aphelion and perihelion distances, might lead in many cases to

an approximate knowledge of the former important element, which is generally indeterminable from ordinary observations at a single apparition.

No very careful measures appear to have been made of the compression experienced by the present comet; but contrasting such as have been procured during a month before the perihelion passage, with Mr Hartnup's important daylight observation on that occasion, a period may be anticipated of certainly more than 180 years.

Tuesday, 3d January 1854.

RIGHT REV. BISHOP TERROT, Vice-President, in the Chair.

The following Communication was read:—

On the supposed Sea-Snake, cast on shore in the Orkneys in 1808, and the animal seen from H.M.S. Dædalus, in 1848. By Dr Traill.

The discussions which arose about four years ago on the animal reported to have been seen on 6th August 1848, by Captain M'Quhae, the officers and crew of H.M.S. Dædalus, in the Southern Atlantic, between the Cape of Good Hope and St Helena, about 300 miles off the African shore, recalled my attention to the materials I had collected respecting the vast animal cast ashore on Stronsey, one of the Orkneys, in 1808.

I was not there at the time, but copies of the depositions made by those who had seen and measured it were transmittted to me by order of Malcolm Laing, Esq., the historian of Scotland, on whose property it was stranded; and I obtained other notes from several individuals resident in Orkney.

The evidence of the most intelligent persons who had seen and measured the animal was carefully collected, and copies of it were transmitted by Mr Laing to Sir Joseph Bankes, and other naturalists. Soon afterwards Mr Laing sent, through his brother, the late Gilbert Laing Meason, to the museum of our university the skull and several vertebræ. The cartilaginous omoplates, to which a portion of the pectoral fin, or *wing*, as it was termed by the natives, were afterwards sent to Edinburgh, where I saw and examined them.

Two of the vertebræ were transmitted to me, with portions of what was termed the *mane* of the animal; which I now exhibit.

The dead animal was first observed by some fishermen lying on a sunken rock, about a quarter of a mile from Rothiesholm-head; but in a few days a violent gale from the S.E. cast it on shore in a creek near the headland, where it remained for some time tolerably entire; and it was subsequently broken up by the fury of the waves. Before it was thus broken into several pieces it was examined, and measured by several intelligent inhabitants of the island; and their testimony, collected as above stated, was forwarded to London, Edinburgh, &c. Their declarations were, however, accompanied by a very absurd suppositious drawing of the animal, which was thus produced. Many days elapsed ere the tempestuous weather allowed any communication with other islands; and when the storm abated, a young man was sent from Kirkwall by Mr Laing, to collect what information he could on the subject. But by this time the body of the animal was completely broken up. This lad, who was no draughtsman, and ignorant of Natural History, endeavoured, from the descriptions of those who had seen the animal most entire, to delineate with chalk on a table a figure of the animal. The rude figure so produced was transferred by pencil to paper, and copies of it were handed about as real representations of the animal.

That it had a general resemblance to the animal was admitted by those who had seen it; but from the accounts I afterwards obtained, it would appear that the *jointed legs*, which the lad had attached to it, are creations of his own imagination.

The appendages, which gave rise to this strange representation, were never called *legs* by those who saw the animal, but were denominated by them *wings*, or *fins*, or *swimming paws*. "That nearest the head was broader than the rest, about four-and-a-half feet in length, and was edged all round with bristles or fibres, about ten inches long." The "lower jaw was wanting when it was cast ashore, but there remained cartilaginous teeth in portions of the jaws." Before it was discovered putrefaction had commenced, especially in the *fins*. The animal had a long and slender neck, on which there were two spiracles on each side.

The *wings* would seem to have been the remains of fins, altered by incipient decomposition. The six may perhaps be remains of pectoral, abdominal, and anal fins, and perhaps they may have been

placed, like those of some of the shark family, farther from the centre of the abdomen than in ordinary fishes. Indeed one of the witnesses states that "the wings of the animal were jointed to the body nearer the ridge of the back than they appear in the drawing."

The portion of the anterior fin or *wing*, which was attached to the omoplates, consisted of cartilaginous rays; and when such a structure of fin is partially separated by commencing decomposition, the rays might easily, to the eyes of the uninitiated in natural science, seem like toes or fingers.

Even the great Cuvier admits this resemblance, when describing the fins of fishes:—

"Des rayons plus ou moins nombreux soutenant de nageoires membraneuses, representent grossièrement les doigts, des mains, et des pieds."

As much of the value of the descriptions of the Orkney animal rests on the character and credibility of the individuals who saw it most entire, I may be permitted to state that I personally knew the three principal witnesses, Thomas Fotheringhame, George Sherar, and William Folsetter, to be men of excellent character, and of remarkable intelligence. They were not *ignorant fishermen*, as the witnesses were represented to be; but two of them were of the better sort of farmers in that part of Orkney; and the first and the last of them were also very ingenious mechanics, much accustomed to the use of the *foot-rule*, the instrument employed in measuring the animal.

They were men of such honour, intelligence, and probity, that I can have no doubt of the correctness of any statement they made of their impressions of what they had so carefully observed.

It was, therefore, not without surprise, that some months after these accounts were sent to London, I read a paper by Mr Home (afterwards Sir Everard), in which he recklessly sets aside the evidence of the persons who saw and measured the animal in its most entire condition, as to its dimensions of length and thickness; and maintains that it was nothing but a Basking shark (*Selache maximum !*), which he supposes the love of the marvellous had magnified so enormously in the eyes of those whom he is pleased to call "*ignorant fishermen.*" Unfortunately for Homo's hypothesis, the Basking shark was probably far more familiar to those men than to himself; for it is often captured among the Orkney islands; and its

length and proportional thickness are so totally different from the animal in question, that the two could scarcely be confounded, by the most "ignorant fishermen" who had ever seen them.

These witnesses assert that the Stronsey animal (though a portion towards the tail was broken off when they took its dimensions) measured no less than fifty-five feet in length; whereas that of the largest Basking shark of which we possess any accurate account, scarcely exceeds thirty-six feet.

The circumference of the two animals is no less widely different. My notes state the circumference at the thickest part of the body of the Orkney animal to be about ten feet; while it tapered much towards the head and the tail; whereas the circumference of a large Basking shark, where thickest, is not less than twenty feet. Besides, the shark-like figure of the latter could scarcely be confounded with the eel-like form of the Stronsey animal.*

The *mane*, as it is termed, may perhaps be the remains of a decomposed dorsal fin; but the fibres do not seem to be the rays of a fin; and the animal seen from the *Dædalus* is stated to have had a mane, floating about like sea-weed; and a similar appendage has generally been noticed in some less distinct accounts of a supposed sea-serpent.

Supposing this to be a dorsal fin, it extended from the anterior *wings*, or pectoral fins, towards the tail for thirty-seven feet, and differs from the dorsal fin of any species of shark. If the *mane* consisted of detached fibres extending for thirty-seven feet on the back, it is analogous to no appendage of any known marine animal. That its rays or fibres are very peculiar, will appear from the specimen now exhibited. These round fibres are fourteen inches in length; and in the dried state, have a yellow colour and transparency, equal to that of isinglass.

The vertebræ, which have been preserved in spirit in our Museum, have been exceedingly well described by Dr Barclay, in the Wer-

* The diameter of the animal is a little differently stated by different witnesses. But as we are told that its contour was more oval than round, we can easily explain the discrepancy. One witness, who had not measured it, speaks of it as equalling a middle-sized horse in thickness. On measuring four horses of from thirteen to fourteen hands in height, I found their greatest circumference to be from seventy-one to seventy-three inches, (or from five feet eleven inches to six feet one inch), or an average of six feet; that is less than the thickest part of our animal, but seemingly near that of its average dimensions.

nerian Transactions, vol. i.; and undoubtedly, in their want of processes and cartilaginous structure, have much resemblance to those of chondropterygious fishes. One of the vertebræ adherent to the cranium, measured only two inches across; while that of the Basking shark, in the same situation, is about seven inches in diameter. Dr Barclay's paper is accompanied by an engraving of the omoplates, and upper portion of the pectoral fin, which are accurately given, from a drawing made from the recent remains, by the late Mr John T. Urquhart, an accomplished draughtsman, and able naturalist. I know the representation to be correct, for I saw and handled the specimen. The substance of this part was a firm, but flexible cartilage, and seemed to have been placed in the muscles; just as Cuvier describes the omoplates of sharks to be: "Leur omoplates sout suspendues dans le chair, en arrière des Branchies, sans articuler ni au crâne ni à l'espine."

The Orkney animal seems to have had *two circular* spiracles on each side of its neck, about 1¼ inch in diameter; whereas the Basking shark has *five linear* spiracles on each side, a foot or more in length.

The cranium, which I also very carefully examined, was far too small for that of a Basking shark of even one-fourth the usual length of that species. It measured in its dried state no more than twelve inches in length, and its greatest diameter was only seven inches. A Basking shark of thirty-six feet long would have had a head of at least five feet in length; and the diameter of the cranium, at the angles of the mouth, would have measured probably five feet. These proportions positively shew, that the Orkney animal could not possibly be confounded by intelligent men, accustomed to see the Basking shark, with that fish. There was a hole on the top of the cranium, something similar to the blow-hole of the cetaceans; but its lateral spiracles and cartilaginous bones forbid us to refer it to the order of cetacea.

Everything proves the Orkney animal to have been a chondropterygious *fish*, different from any described by naturalists; but it has no pretensions to the denomination of *Sea-serpent* or *Sea-snake*, although its general form, and probably its mode of progression in the ocean, may give it some resemblance to the order of *Serpentes*. Certainly, it cannot be confounded with any known shark; nor does it belong to the family of Squalidæ.

The belief in the existence of a huge marine animal, of an enormous length, which has obtained the name of *Sea-serpent*, is still very general among the Norwegian fishermen, and is said to have been seen lately in some of their *fiords*. A singular notice of it was long ago published by Bishop Pontoppidan, in his History of Norway; but, unfortunately, in his pages, it was introduced in the suspicious company of the *Kraken* and the *Mermaid;* and therefore has been rejected by later naturalists.

I am satisfied, however, that the extravagant descriptions which northern authors have given of the *Sea-serpent*, have been founded on the rare appearance of some such animal as that driven on shore in Orkney; which may also have been the prototype of the dark sublimity of the wondrous sea-snake of the Scandinavian Edda. That in the ocean such animals do exist, has been affirmed by persons worthy of credit. I shall notice an unpublished instance, related to me many years ago by my intelligent friend, the late Mr Andrew Strang, a gentleman of unblemished honour. "Once, when on a deep-sea fishing, he saw pass below his boat, at the depth of eight or ten feet, an enormously long fish, of an eel-shape. It was swimming slowly, with a vermicular motion, and appeared to be at least sixty feet in length." It appeared to take no notice of them; but they hastily removed from what they considered a dangerous neighbourhood. He stated that he was shy of mentioning this circumstance, "lest the sceptical public should class him with the fable-loving Bishop of Bergen." There is considerable reason to believe that a similar fish has appeared more than once on the western coasts of Scotland.

I shall not here discuss the notices we have, from time to time, received of late years of a great *Sea-serpent* seen by mariners in crossing the Atlantic to America. Their accounts are generally confused, sometimes evidently fabulous; and, in some instances, it would seem that the narrators have mistaken a shoal of porpesses or other delphinoid animals, for a huge sea monster.

The bones exhibited by Koch, at New York and Boston, as those of a fossil *Sea-serpent*, which were afterwards brought to Berlin, have been proved to be a most disingenuous fraud of the finder, who united the bones of different individuals of an extinct species of whale; bones now proved by Professor Muller to belong to animals of very different ages, and by M. Agassiz "to have been dug up at different localities." Several diminutive snake-like animals have

been killed on the shores of America; as that taken at Cape Anne in 1817, which is figured in the *Illustrated London News* of 28th October 1848, from the original American memoir. Neither the *Saccopharynx* of Mitchell, nor the *Ophignathus* of Harwood, can be considered as the animal we have described. The *Saccopharynx* is said to be 4½ feet long; the *Ophignathus* was six feet. Neither of them in size or form will, in the language of Mr Owen, "satisfy the conditions of the problem."

I must except from this category, however, the animal seen from H.M.S. *Dædalus;* and the account of it given by Captain M'Quhae and his officers. In their statements there are no suspicious affectations of minute detail. Their simple narrative appears to deserve more attention than it has yet received from naturalists; and I strongly incline to the belief, that the animal seen by the crew of the *Dædalus* was an analogue of, if not the very same species, as the animal cast ashore in Orkney in 1808.

Considering the derision with which, in this country, the subject of the *Sea-serpent* has been treated, and the ridicule attempted to be thrown on all who were bold enough to assert that they had seen such an animal, nothing but a consciousness of his unimpeachable veracity could have tempted the gallant Captain M'Quhae to encounter the sneers of his incredulous countrymen. From all I have heard of his character for sagacity and veracity, from those who intimately knew him, I have not the smallest doubt that he has faithfully described what he and his crew saw distinctly, and at a short distance from the ship.

The animal seen from H.M.S. Dædalus on 6th August 1848, *in lat.* 24° 44′ S., *long.* 9° 22′ E.—"It was seen rapidly approaching before the *beam*." Captain M'Quhae says: "On our attention being called to the object, it was discovered to be an enormous serpent, with head and shoulders kept about four feet constantly above the surface of the sea. The diameter of the serpent was about fifteen or sixteen inches behind the head; its colour of a dark brown, with yellowish-white about the throat."

The Captain could discover no fins, but "something like the mane of a horse, or rather a bunch of sea-weed, washed about its back." He thought that its head did certainly resemble that of a snake; but the drawing which he transmitted to the Admiralty has not, to the eye of a naturalist, the form of that of any snake. The

figure published in *The Illustrated London News* for October 28, 1848, is said to be an accurate copy of that drawing.

Captain M'Quhae estimates the length of its body at the surface of the water, "*à fleur d'eau*, at the very least equal to sixty feet, no part of which was to our perception used in propelling it through the water, either by vertical or horizontal undulations. It passed rapidly, but so close under our quarter, that had it been a man of my acquaintance, I should easily have recognized his features with the naked eye; and it did not, either in approaching the ship, or after it had passed our wake, deviate in the slightest degree from its course to the S.W., which it held on at the pace of twelve or fifteen miles an hour, apparently on some determined purpose."

If we may judge from the engraving, the cranium is very convex, of moderate size, with a short obtuse muzzle, a mouth reaching beyond the eye; which last organ is round, and of a moderate size. The surface of the body is represented as smooth, and destitute of scales—of which they were enabled to judge, because it passed close under the *quarter* of the ship. It was in sight for twenty minutes.

The description certainly does not belong to any Ophidian; and as certainly militates against an opinion thrown out by Mr Owen, that it might be a specimen of the *Leonine seal*, which has, it is alleged, occasionally reached those latitudes. The Leonine seal never exceeds twenty-five feet in length, and such would have a circumference at its shoulders of twenty feet, while this appears to be eel-shaped, with a diameter of not more than fifteen or sixteen inches behind the head. The mane, too, of the male of the Leonine seal extends only over the head and neck; but in the other, it extended down the back.

With all deference to so eminent a naturalist as Mr Owen, I humbly conceive that his conjecture respecting the identity of Captain M'Quhae's animal with the Leonine seal, is not more probable than Home's identification of the Basking shark with the Orkney animal.

Both M'Quhae's and the Orkney animal would appear to be cartilaginous fish, totally different from any genus known to naturalists.

2. Further Researches on the Crystalline Constituents of Opium. By Dr Thomas Anderson.

The following Gentleman was elected an Ordinary Fellow :—

Sir JOHN MAXWELL of Poloc, Bart.

The following Donations to the Library were announced :—

Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. No. 43. N. S. 8vo.—*From the Society.*

Medico-Chirurgical Transactions. Published by the Royal Medical and Chirurgical Society of London. Vol. XXXVI. 8vo.—*From the Society.*

Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. Sciences. Mathématiques et Physiques. Tome V., 5 & 6 Liv. 4to.—*From the Academy.*

Astronomische Beobachtungen auf der Königlichen Universitäts Sternwarte in Königsberg. Angestellt und herausgegeben von Dr A. L. Busche. 25te Abtheilung. Fol.—*From the Observatory.*

Monday, 16*th January* 1854.

SIR T. M. BRISBANE, Bart., President, in the Chair.

The following Communication was read :—

What is Coal? By Dr Fleming.

Dr Fleming, after stating the circumstances which led him to bring before the Royal Society the consideration of this question, pointed out the distinction between a *mineral species* and a *rock*, a circumstance which had been greatly overlooked in recent discussions on the subject. He considered coal as a rock, and capable of being traced, in its origin and history, from peat at the beginning of the series, to blind coal or anthracite at the termination.

He illustrated the character of peat in reference to the vegetables from which it was derived—the changes of a mineralizing nature which it had undergone—and the strata of sand, clay, and marl with which it is usually associated. He likewise pointed out the character of the lustrous streak and conchoidal fracture in specimens exhibited.

The author next proceeded to the consideration of wood coal, or lignite, and exhibited specimens of this rock with and without the woody texture—with a brown and black streak—with a lustrous and dull streak—and with the ligneous structure, and as cherry coal, undistinguishable from the same rock in the older measures. He closed his remarks on the brown coals by adverting to the *coal-money* of the Kimmeridge coal, and to the condition of *amber* as belonging to this epoch.

In the third and concluding part of his paper, he pointed out the characteristic features of the four kinds of coals found in the coal measures. The lustre, fracture, and streak, from exhibited specimens, he demonstrated to be variable and unsatisfactory as characters; while chemical test indicated the absence of bitumen. He adverted to the different kinds of matter occurring in coal as indicated by the microscope, and exhibited specimens of seeds dispersed through splint and cherry coal. He concluded his remarks by adverting to cannel coal, as exhibiting, in its varieties, the conchoidal and slaty fracture, the lustrous and dull surface and streak; and in reference to the Boghead cannel or gas coal, adverted to in this Society as the "Torbanehill mineral," and denominated "bitumenite" by Dr Traill, he considered, all the characters employed to remove it from its position as a *cannel coal*, as variable, differing in degree not in kind, and not generally recognised.

The following Gentleman was elected an Ordinary Fellow:—

William Murray, Esq. of Monkland, F.G.S.

Monday, 6*th February* 1854.

Right Rev. BISHOP TERROT, Vice-President, in the Chair.

The following Communication was read:—

Observations on the Structure of the Torbanehill Mineral, as compared with various kinds of Coal. By Professor Bennett.

Monday, 20th February 1854.

JOHN RUSSELL, Esq., P.C.S., in the Chair.

The following Communications were read:—

1. Account of the Proceedings of the Conference held at Brussels in August and September last, for establishing a uniform system of Meteorological Observations in the Vessels of all Nations, and of the arrangements proposed to be made for conducting the results of the Observations taken on Land with those taken at Sea. By Captain H. James, R.E., F.R.S, &c. Communicated by James Wilson, Esq.

2. On certain Vegetable Organisms found in Coal from Fordel. By Professor Balfour.

The author stated that the coal to which he called attention was found at Fordel collieries, near Inverkeithing, Fife, and that he was indebted for specimens of it to Mr Robert Daw, comptroller of customs at Leith. It is a splint coal, and exhibits numerous vegetable impressions, particularly of Sigillaria and Stigmaria. These plants appear, indeed, the author thought, to have formed the main substance of the coal, as shown not only by its external appearance, but also by its microscopical structure. Cellular and woody tissue have long been recognised in coal; but from what is now seen in the Fordel and other varieties, it would appear that scalariform and dotted tissue are often present, and, moreover, that in some instances peculiar dotted vessels have been mistaken for true punctated woody tissue. Elongated cavities, containing yellow and orange-coloured matter, also occur in Fordel coal. These cavities did not appear to be woody tubes, from which they differed in their form and arrangement, as well as in occasionally branching. They seemed in this, as in many other coals, to be more of the character of intercellular spaces or canals. The coal from Fordel also contains numerous specimens of seed-like bodies, which appear to be sporangia, allied to those of Lycopodiaceæ. These bodies have a rounded form; their colour is dark-brown, and they seem to be formed by two valves, which are occasionally separated. When one of the valves is removed, there is frequently ob-

served a black carbonaceous mass below it; and when a transverse section is made of an entire sporangium *in situ*, the cavity between the valves is often evidently seen. At one part of the sporangium a stalk-like process is sometimes observed. These sporangia seem to resemble much those organs of fructification in Lycopodiaceæ which contain the small spores, commonly known as vegetable sulphur or Lycopode powder, and it seems probable that the dark contents of the Fordel sporangia may be the altered spores.

Large spore-like bodies are also met with in coal, which may perhaps be similar to the larger spores of Lycopods. It is by no means improbable, the author thought, that the sporangia in the Fordel and other coals may be the fructification of Sigillaria,—a genus which occupies an intermediate position between Cycadaceæ and Lycopodiaceæ. The Fordel coal also contains abundance of the inflammable resinous organic matter called Middletonite, which, according to the author, may perhaps be in some way connected with the sporangia just noticed.

Specimens were shown of Fordel coal formed by Sigillariæ and Stigmariæ, and of the same coal containing sporangia and Middletonite, while the communication was illustrated by magnified drawings of structure.

The following Gentleman was elected an Ordinary Fellow:—

Dr John Addington Symonds, of Clifton, Bristol.

Monday, 6th March 1854.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read:—

1. On the Impregnation of the Ova of the Salmonidæ. By John Davy, M.D., F.R.S. Lond. & Edin., Inspector-General of Army Hospitals.

The author has been induced, he states, to make inquiry on this subject, in consequence of a recent averment, founded on a reported experiment, that the ova of the trout taken from the abdomen of the parent fish, and not afterwards mixed with the milt, have proved prolific.

He first gives an account of many trials made to test the accuracy

of the conclusion that the ova of the Salmonidæ may be impregnated *ab externo*, the results of all which have been negative, and remarkably contrasted with those in which, after exclusion, the milt and roe have been mixed,—impregnation having been effected and the eggs rendered prolific.

Secondly, he notices the generative organs of these fishes, and points out how, anatomically, they are clearly unfit for performing the reproductive function according to the hypothesis of impregnation *ab externo*, though perfectly adapted for it in accordance with the received doctrine.

Thirdly, he adverts to the manner in which, during the spawning season, the male and female fish approach each other, as being also in accordance with the same doctrine, and opposed to the inference of internal impregnation.

In conclusion, he observes, that even admitting the accuracy of the detail of the experiment adduced to prove such a mode of impregnation, the conclusion drawn is not a necessary one,—inasmuch as the ova included in a perforated box and placed in a stream, may have been impregnated by milt shed in the adjoining water, and by it in its flow conveyed to them.

2. Account of a remarkable Meteor seen on 30th September 1853. By William Swan, Esq.

On the 30th September 1853, I was with my friend Mr David Wallace, in a field near his house, Balgrummo, in the neighbourhood of Leven, in Fifeshire. The atmosphere was very clear, and the sun was shining brightly. The sky was covered in some quarters with thin cirrous clouds, and we had been watching the changes in the appearance of the clouds nearly overhead, when Mr Wallace, who was still observing the sky, pointed suddenly upwards, and called on me to look. I did so, and instantly saw a round body, apparently as large as a star of the first magnitude, moving rapidly upwards, —roughly speaking, towards the zenith, or more accurately, towards the sun. This, as I immediately afterwards ascertained, was about $11^h\ 15^m$ Greenwich mean time.

The region of the sky which the meteor traversed was cloudless and serene, so that I had an extremely favourable opportunity of observing it, and I continued to see it for about a second of time.

As it moved upwards through the sky, its apparent magnitude diminished with such perfect regularity until it finally disappeared, that at the time I had the impression that it had vanished, not by dissolution of its parts, or extinction of its light, but only optically, from the effect of increased distance. I do not wish, however, to attach much importance to this nearly momentary feeling, for the observation was of too transitory a nature to make it deserving of much confidence.

The meteor appeared to me not like a self-luminous body; although, in the presence of so bright an object as the sun, negative evidence on such a point cannot be regarded as decisive. Its colour was perfectly white, and its apparent brightness was probably not greater than that of the moon seen under similar circumstances,—certainly it did not exceed that of an ordinary cloud illuminated by the sun.

Mr Wallace, as soon as he had time to recover from the surprise excited by so unusual a spectacle described what he had seen as one of the most beautiful phenomena he had ever beheld. It will be recollected that it was he who first pointed out the meteor to me; and having been the first to notice it, he had thus also been able to observe some interesting changes in its form which I was too late to witness. By his kindness I am enabled to state what he saw in his own words.

"On the forenoon of the 30th September last," he says, "I was in a field distant about five hundred yards from Balgrummo house, and about a mile and three quarters from Leven. The sky was rather free from clouds, and the sun was shining brightly. I happened to look in the direction of Lethem farm-house, when I was startled by observing a remarkable object, apparently traversing the atmosphere with a steady motion resembling that of a balloon, but much quicker. It appeared to me to be not perfectly round, but somewhat pear-shaped; and it had a lustre like quicksilver, but seemed more transparent. Its movement was upwards like a rising balloon, and not downwards like a 'falling star.' I only saw it for two, certainly not for more than three seconds; and its direction, as nearly as I could judge, was from N.E. to S.W. It appeared to preserve its original shape for about half the time during which it remained visible; but it then seemed to burst at the lower part into a number of fragments, which one by one disappeared, until it finally vanished altogether.

Its size at first seemed to be about one-third less than the apparent diameter of the moon; and I could have supposed it to be in our own atmosphere."

From the apparent size of the meteor, and its perfectly round form as seen by me, contrasted with its much greater magnitude as estimated at first by Mr Wallace,—its train,—its separation into fragments,—and its final round form as described by him, coupled with the fact that he saw it for some time before me,—I conclude that I had only seen the meteor in the last of the phases which he describes. It seemed to me to have a very striking resemblance to the shooting stars so frequently visible by night. It was not, indeed, so luminous as such objects usually appear to be, but that was not to be expected in the presence of the sun; and, I have no doubt, had it been seen by night, it would have proved a very brilliant object indeed.

I may add, that the meteor was not accompanied by any sound, and that its path was sensibly rectilinear.

As I hoped to obtain accounts of the meteor as seen from other stations, I deemed it desirable to ascertain, as far as was practicable, the positions of the points in the heavens where its most remarkable phases occurred. In the absence of stars, which by night afford such convenient points of reference, I endeavoured, with Mr Wallace's assistance, to estimate the altitudes and azimuths of the principal points in the path of the meteor; and as soon as I could command time I returned to the spot, in company with Mr Wallace; and by means of a prismatic compass determined the azimuths of these points, while their zenith distances were measured by means of a quadrant, which, although rude, was sufficiently accurate for my purpose. The true azimuths were deduced from those which were observed, by subtracting the variation of the compass, which was found to be 25° 20′ W. The variation was determined from the azimuth of the sun, observed by the compass; the latitude and longitude of the station deduced from data kindly furnished by Captain Henry James, R.E.; and the time given by a pocket chronometer, carried in its box, and compared with the Edinburgh time-ball.

The following are the positions of the most remarkable points in the meteor's path:—

	Apparent Zenith distance.		Azimuth.			
Meteor appeared, .	70°	37′	North 2°	59′	East.
Meteor burst, . .	57	40	„ 7	48	„
Meteor disappeared,	47	30	„ 10	49	„

The station where the meteor was seen is situated very nearly in latitude 56° 13′ 5″ N., longitude 12^m $2^s{\cdot}6$ W.

It is worthy of remark, that as the meteor was seen at 11^h 15^m, Greenwich mean time, if allowance is made for the longitude of the station and the equation of time, it follows that it appeared about 48^m before apparent noon, or about that time of day when the sun shines most brightly. Now, while many accounts are extant of meteors which have appeared during the day, and have attracted attention by exploding audibly, or have been accompanied by the descent of meteoric stones, I was not aware that any object like the meteor of the 30th September, resembling so closely the more tranquil phenomena of shooting stars, had been described as being seen within an hour of noon, and in bright sunshine. I was, therefore, desirous of obtaining other observations of the meteor, and for that purpose I sent a short account of it to one of the Edinburgh newspapers, requesting the favour that any observations of it made elsewhere might be communicated to me, in order that they might be incorporated with this narrative. I have not, however, had a single communication on the subject,—a result which, although it is to be regretted, yet does not surprise me; for, from the faint illumination of the meteor, it was an object which would scarcely *attract* observation, although it was easily perceptible to an eye which, like my friend's, was already directed to the region of the sky where it appeared.

3. On the Mechanical Action of Heat. By W. J. Macquorn Rankine, C.E., F.R.SS. Lond. & Edin., &c.

Section VI. *Subsection* 4.—*On the Thermic Phenomenon of Currents of Elastic Fluids.*

Supplement.—Of a Correction applicable to the results of the previous reduction of the experiments of Messrs Thomson and Joule.

In investigating the phenomena of the free expansion of gases in the previous part of this paper, they had been considered as expand-

ing, without receiving or giving out energy in any form; so that the equation taken to represent their condition was

$$\Delta \Psi = 0.$$

This condition was realized in the early experiments of Mr Joule, where, by the sudden opening of a stopcock, air previously confined in one vessel was allowed to fill another also; but it is not exactly realized in the experiments now in progress by Messrs Joule and Thomson, for which the correct equation is

$$\Delta (\Psi + P V) = 0.$$

Hence the approximate positions of the point of absolute cold calculated by means of the former equation, require a small correction. The author computes the values of this correction for two series of experiments, made at a high and a low temperature respectively; and finds them to be—

$+ 0^\circ{\cdot}05$ Centigrade for the high temperature,
$- 0^\circ{\cdot}002$ Centigrade for the low temperature;

so that for the experiments now in question, the correction is practically inapplicable. As it may, however, have a sensible amount for greater ranges of temperature and pressure than those which occur in the particular experiments referred to, and for gases denser than atmospheric air, the author explains how it is to be calculated.

The following Donations to the Library were announced:—

Lectures on Quaternions. By Sir William R. Hamilton. 8vo.—*From the Author.*

Fourth Report of the Council of Management of the Architectural Institute of Scotland. 8vo.—*From the Institute.*

Memoirs of the American Academy of Arts and Sciences, (N. S.) Vol. V., Part 1. With Map of Toronto. 4to.

Proceedings of the American Academy of Arts and Sciences. Vol. II. From May 1848 to May 1852. 8vo.—*From the Academy.*

Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. No. 44. (N. S.) 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVI., Part 4. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Second Series. No. 49. 8vo.—*From the Editors.*

Journal of the Horticultural Society of London. Vol. IX., Part 1. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Edited by the Secretaries. No. 5. 1853. 8vo.—*From the Society.*

The Assurance Magazine, and Journal of the Institute of Actuaries. No. 14. 8vo.—*From the Institute.*

Thirty-third Report of the Council of the Leeds Philosophical and Literary Society. 1852–3. 8vo.—*From the Society.*

Jahresbericht über die Fortschritte der reinen, Pharmaceutischen und Technischen Chemie, Physik, Mineralogie und Geologie, &c. Herausgegeben von Justus Liebig et Hermann Kopp. 1847–50. 8vo.—*From the Editor.*

Bulletins de l'Academie Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Tome XX. 8vo.—*From the Academy.*

Flora Batava. 174 Aflevering. 4to.—*From the King of Holland.*

Mémoires Couronnées et Mémoires des Savants Etrangers, publiés par l'Académie Royale des Sciences de Belgique. Tome V. 2de Partie. 8vo. Two copies.—*From the Academy.*

Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo III. 4to.—*From the Academy.*

Acta Societatis Scientiarum Fennicæ. Tom. III., Fasciculus 2. 4to. —*From the Society.*

Notiser ur Sällskapets pro Fauna et Flora Fennica Förhandlingar. Pt. 2. 4to.—*From the Society.*

Della Instituzione de' Pompieri, dal Francesco del Giudice. 4to.

Rendiconto delle Sessioni dell' Accademia delle Scienze dell' Istituto di Bologna. 1851–2. 8vo.—*From the Academy.*

Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tome XXVII. 4to.—*From the Academy.*

Mémoires sur les Variations Périodiques et non Périodique de la Témpérature. Par A. Quételet. 4to.

Observations des Phénomènes Periodiques. Par A. Quételet. 4to. —*From the Author.*

Mémoires de la Société des Sciences Naturelles de Cherbourg. 1er. Vol. 2e Liv. 8vo.—*From the Society.*

A History of the Fishes of Massachusetts. By David Humphreys Storer, M.D., A.A.S. 4to.—*From the Author.*

Maritime Conference, held at Brussels, for devising an uniform System of Meteorological Observations at Sea, August and September 1853. 4to.—*From the Belgian Academy.*

Monday, 20th March 1854.

Sir T. M. BRISBANE, Bart., President, in the Chair.

The following Communications were read :—

1. On the Total Invisibility of Red to certain Colour-Blind Eyes. By Dr George Wilson.

After some remarks on the peculiar difficulties which attend investigations into the functions of the eye, the author observed, that by far the most remarkable variety of colour-blindness, in a scientific point of view, is that which shows itself in the identification of red with black. This appeared to have been overlooked by previous observers, or at least only cursorily described. The probable causes of this neglect were noticed; and the author then proceeded to detail the experience of some twelve parties by whom various objects of a red, crimson, or scarlet colour were mistaken for black, and appeared, from the testimony of those who committed the mistakes in question, to have made neither a colorific nor a luminous impression on the retina. It was further shown, that though the fact had not attracted attention, the published cases of colour-blindness supplied examples of the same blindness to red; and that Dalton, although he had apparently ascertained his own freedom from the blindness in question, had incidentally supplied proof that the red alike of the solar spectrum and of coloured objects frequently appeared to him as dark or nearly black.

Experiments were also recorded, which had been made by the author, with the assistance of Professor Kelland, on the visibility of prismatic spectra to persons affected by colour-blindness, one of whom was found unable to perceive from $\frac{1}{6}$th to $\frac{1}{8}$th of the red end of the solar spectrum, whilst the other could not discern $\frac{1}{3}$d of the

red. These parties showed a similar degree of blindness to the red of the lime-ball-light spectrum, and neither of them saw any other colour in place of the missing one, or received a luminous impression from the less refrangible rays of solar or artificial light.

From his entire observations, the author drew the conclusion, that the confusion of scarlet with green, and of pink, crimson, and purple with blue, which characterises the colour-blind, is a phenomenon of the same kind as the confusion of red with black—scarlet appearing as green, because it is seen as yellow mixed with black—and crimson as blue, because it is seen as red mixed with black.

The author referred, in conclusion, to the observations of Brewster and Dove on the visibility of red to normal eyes, as proving that they became blind to this colour in dim or unfavourable light, much sooner than to blue, not to mention yellow; so that, in the colour-blind, we only see an exaggerated manifestation of a limitation of vision which belongs to all eyes.

2. On the Romaic Ballads. By Professor Blackie.

The following Donations to the Library were announced:—

The Quarterly Journal of the Geological Society. Vol. X., Part 1. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVII., Part 1. 8vo.—*From the Society.*

Journal of the Royal Geographical Society. Vol. XXIV. 8vo.

General Index to the Second Ten Volumes of the Journal of the Royal Geographical Society. 8vo.—*From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool. 1851–3. No. 7. 8vo.—*From the Society.*

A Collection of Tables, Astronomical, Meteorological, and Magnetical. By Lieut.-Colonel J. T. Boileau. 4to. 5 Copies.—*From the Directors of the Honourable East India Company.*

Mémoires de l'Academie Nationale des Sciences, Belles Lettres, et Arts de Lyon. Classe des Lettres. Tome 1er. 8vo.—*From the Academy.*

Mémoires de l'Académie Nationale des Sciences, Belles Lettres, et Arts de Lyon. Classe des Sciences. Tome 1er. 8vo.—*From the Academy.*

Monday, 3*d April* 1854.

Dr CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. On a New Hygrometer, or Dew Point Instrument. By Professor Connell.

This instrument consists essentially of a little spherical bottle of thin brass, polished externally; a small exhausting syringe; a thermometer with ground brass stopper; and a brass clamp. The bottle has a diameter of $1\frac{2}{10}$ inch, and is capable of holding half an ounce. Its neck is attached to the syringe by means of a lateral screw, and is three-fourths of an inch high, and about three-tenths of an inch wide. The syringe is about five inches long, and has a diameter of eight-tenths of an inch. The stopper attached to the thermometer fits air-tight into the upper part of the neck of the bottle. The clamp is intended for securing the instrument to the sill of an open window, or to a table or other fixture in a room. Three drams of ether are then slowly introduced into the little bottle, and the thermometer inserted. The syringe is worked slowly at first, and the speed gradually increased, when the thermometer will immediately begin to fall from the cold produced by the evaporation; and the exhausting process is continued until dew is seen to be deposited on the external surface of the little bottle. The temperature indicated by the thermometer is then noted, the process of exhaustion stopped, and the temperature again noted when the dew disappears from the brass surface. The mean of these two observations may be taken as the dew point. To prevent the spreading of the heat produced by the friction of the piston, to the little bottle, the termination of the syringe which screws into the neck of the bottle is constructed of ivory; and as it is found that the vapour of the ether acts on valves of the usual oiled silk, they are constructed of goldbeater's leaf, four plies of it being used for each valve. A reduction of temperature, varying under different circumstances of temperature from 20° to 40°, has been produced by the instrument; and should it ever be found that extreme cases of united cold and dryness of atmosphere shall occur, which are not within the power of the present size of the instrument, there is little doubt that a sufficient increase of re-

ducing energy may be attained by a moderate increase of the size of the syringe.

The amount of ether consumed in an observation rarely exceeds half a dram, and frequently falls a good deal short of this, the cost thus being from a halfpenny to a farthing. The residual ether may be repeatedly employed, making up its amount each time to three drams from fresh ether. It ought to be kept for use in a separate little bottle. The leather of the piston ought to be occasionally rubbed with olive oil, and the washers of the connecting screws ought not to be allowed to become too dry. The syringe must be of the most approved construction, and all the apertures of the neck of the bottle and of the valve-piece sufficiently wide. Comparative observations have been made regarding the indications of this instrument, of Daniell's hygrometer, and of Dalton's mode of transference of a cold liquid from one vessel to another, which last is usually admitted as a kind of standard of compression. Those of Daniell are usually a very little in excess, and those of this instrument a very little in deficiency; but the deviation of both is on an average within 1° Fahrenheit.

The instrument is constructed by Messrs Kemp of Edinburgh, with the proper accompaniments of measure, bottles for ether, &c., all packed in a little box. It is thought that it will be found to offer advantages in point of considerable security from accidental fracture in travelling.

2. On the Stability of the Instruments of the Royal Observatory. By Professor Piazzi Smyth.

In an observatory where, as in that of the Calton Hill, the principal object of pursuit is the determination of the exact places of the fixed stars, and the investigation of those exceedingly slow secular variations, which require many thousands of years to run their cycle,—the stability of the instruments, as a necessary element to the accuracy of the observations, becomes of the extremest importance.

To secure this quality much invention and no little ingenuity have been employed, but not yet with perfect success; for invariably the more accuracy we demand, the more insuperable difficulties appear to arise. Even nature at last appears to be taxed beyond her powers, for we find when we have passed beyond a certain degree of magnifying power, that there are no bodies absolutely stiff and rigid—none constantly of the same dimensions; but all are expanding and con-

tracting, and giving and limiting with every change of temperature or application of small accidental pressures. All this takes place, it is true, within limits which are perfectly inapplicable to ordinary observation, but are of the utmost importance to be attended to in astronomical inquiries. And so certain is it that changes and distances must exist in some shape and some form in every case, that if any one observer was hardily to declare that his telescopes kept their adjustments perfectly, or had no error, the statement would only be looked on by astronomers as proving that his observations were very rough and inaccurate.

The most prejudicial form in which the effects of instability can manifest themselves, is in any irregular motion of the stands whereon the instruments rests.

This is usually guarded against by constructing these stands in the shape of large and heavy blocks of masonry, the heavier the better. But even when the greatest practicable size has been reached, perfect immunity from disturbing influences is not obtained. This was signally experienced at Greenwich some years ago, when a telescope was firmly built into a large stone pier, with the view of making such very exact observations of a certain star, as to be able to ascertain its annual parallax. But long before the year was elapsed, it was found that the measures were absolutely vitiated, by the irresistible swelling of the hill from rain, and the consequent heaving up of one end of the pier.

Experience therefore drew the rule, that in addition to the utmost security which a large mass can give to the pier, it is proper to introduce some principle of reversal in the instrument placed upon it. For with such a method, the exact state of adjustment of the whole can be ascertained for any instant. Then it will probably be found that the structure, the permanence of whose position could not be depended on for a year, may be relied on from day to day, if not implicitly, at least to within far less than the limits of the probable error of observation.

In the Edinburgh Observatory both these principles have been long since introduced, and have lately been carried further towards perfection.

The stone piers, for instance, which were erected by our respected member Mr Jardine, are models of excellent masonry, composed of peculiarly dense material, in the largest available blocks; and what is more important, they are founded on the hard porphyry rocks of

the hill. Had they been bedded on gravel or clay, or the softer rocks that the English Observatories are generally confined to, they might have been subject to dangerously irregular movements, owing to the infiltration of water in the soil. But twenty years of careful observation here have not detected any effect of this sort, though they have shown, in the piers of the *transit instrument*, the existence of a small annual displacement of their tops, caused apparently by a difference in the expansion from temperature of the two shafts, though they were purposely cut out of the same bed in the quarry. But as this displacement, even at its maximum, reaches only to 0·001 inch, and proceeds very regularly, its effects on the observations may easily be guarded against.

The second principle above alluded to, viz., that of reversal, was not introduced into the Edinburgh transit in a perfectly unexceptionable manner. At the time of its construction it was certainly thought well of. But, with the usual unhappy tendency to run to extremes, men had no sooner discovered that mere weight in the piers, and the telescopes resting on them, was not a guarantee for their perfect stability, and that the reversing was a necessary adjunct—than they began immediately to attend almost solely to this latter feature, and to make the instruments so slight and delicate, as to require constant reversing. Especially vicious, too, was the then plan of making the metal bearings, through the intervention of which the instrument rested on the pier; for they were made so small, and so weak, and of such a complicated construction, that the good qualities of the masonry, such as they were, became neutralized, and very much larger and more uncertain errors were introduced.

From this source arose those various fluctuations in the position of the transit instrument which I had the honour of describing to the Society in 1847. They had been first detected by my predecessor, and were finally traced up theoretically by myself, to the unequal expansion of certain adjusting screws in the Y block. Now these adjustments should never have been there; and was precisely a reason why the Y block could *not* be firm. They were introduced with the vain idea of enabling the astronomer each day to screw up the instrument to perfect truth before he began his observations. But Professor Henderson knew very well, that after a screw is once touched, it does not attain its true bearing for days, and sometimes for weeks; and he knew also that the *quantity* of any error can be measured numerically much more easily than it can be corrected

mechanically. He therefore adopted the very proper plan of leaving the adjusting screws untouched, but of measuring the amount of error each day, and calculating the effect thereof on the observations.

Still the adjustable Y could not be so firm as a plain block; and being at last pretty plainly convicted of producing the bad effects already described, a necessity came for introducing new and firmer bearings. I can now describe the mode in which this was effected, and the astronomical results which have followed. I applied first to the German maker of the instrument, but found him far too fearful of leaving the old beaten paths of instrument-making to attempt any improvement. Next, therefore, I applied to Mr John Adie of this city, and am happy to say that he carried out my designs in a perfectly satisfactory manner, and so caused the Edinburgh transit to be the first in which this signal improvement has been made; for its advantage is now recognised, and has been adopted elsewhere.

The new Ys are now large blocks of cast-iron, of the whole area of the top of the pier, and weighing as many hundredweights as the old Ys did single pounds. They have, moreover, no adjustments; but the notches in which the pivots of the instrument rest were filed, by repeated trials, to within a certain small quantity of the truth, and have since only been subjected to examinations for the quantity of error. The result, now tested by many years, has been highly satisfactory. For, firstly, they have never been so far out as to require a second filing, or to be out of the limits of convenient calculation; and, secondly, what small amount of variation of position they have been found liable to, has been almost entirely the slow and regular expansion of the piers already alluded to. There has been certainly a difference in the amount of wear of either Y; but this has been exceedingly small, and has very regularly increased with the time, while the large anomalous and irregular fluctuations, which were the dangerous features of former years, seem to be effectually removed. Even when labouring under this drawback, the Edinburgh observations, though not all that they might have been, were at least equal in accuracy to those of any other observatory; so that I trust that they will still, through this alteration, be enabled to keep up their comparative character, whatever improvements may have been made elsewhere.

As a specimen of the increased regularity now of the march of the instrument in its annual temperature movement, I subjoin the observed errors of similar periods of the years 1841 and 1851:—

1841.			1851.		
April	21	+ 0·46 sec.	April	21	− 0·04 sec.
„	23	+ 0·53 „	„	23	− 0·14 „
„	27	+ 0·28 „	„	26	− 0·00 „
„	29	+ 0·16 „	May	15	− 0·12 „
May	3	+ 0·36 „	„	22	− 0·17 „
„	10	+ 0·14 „	June	10	− 0·10 „
„	21	+ 0·27 „	„	25	− 0·18 „
„	28	+ 0·02 „	„	27	− 0·19 „
June	1	+ 0·05 „			
„	4	+ 0·27 „			
„	10	+ 0·46 „			
„	27	+ 0·30 „			

But in addition to the stability of the instruments of an observatory being affected by the slow movements detailed above, it may be injured by quick vibratory motions, not producing permanent change of place. This is, moreover, precisely the sort of inconvenience generally expected on a rocky foundation. Under such a prejudice too was it, that at the first meeting of the British Association in Edinburgh, several of the members, somewhat too hastily, assumed, from their previous prejudices against rock, that the Calton Hill was by no means suitable for an observatory, and declared that good observations could never be made there. But though this unfounded opinion was refuted publicly almost as soon as published, by Professor Wallace and others, good men of the day, and has since been more formally put to the rout by Professor Henderson's long and excellent series of published observations; yet the cry having once been raised, a lingering echo seems still to exist in some persons' minds, that the Calton Hill, because it is rock, is always in such a state of tremor as to preclude the efficient performance of the instruments. And, worse still, only last summer, on a certain public occasion, one of the very gentlemen who in 1834 showed such want of discretion and judgment, again made a similar exhibition of himself. For putting out of sight the facts of all the thousands of Edinburgh Observations, since printed and published, he stated in a public place, that the British Association had declared that the site of the Edinburgh Observatory was not a proper one for an astronomical establishment, and that no good observations could ever be made there, leaving it of course to be inferred that no proof to the contrary had ever been since advanced, and that the dictum held still; and was that of the Association as a body; which it never was.

With gentlemen who will adhere to a favourite theory of their youth, in spite of all the myriads of facts contained in the volumes since published by the Observatory, I fear that the few additional ones which could be condensed into this paper would make but small impression. Some very peculiar instances, however, can now be brought forward; for there are at present in the neighbourhood far more powerful shaking influences than in those former days, and the existing instrumental means are more sensitive than ever to detect vibrations.

These increased means of shaking are the introduction of railways into the vicinity of the Observatory, and the running along them at high velocities of long and heavy trains, creating a far greater disturbance in the soil than the rumbling of any number of carriages along Waterloo Place.

The improved method of detecting the effect of this disturbance is the recent adaptation of the collimating eyepiece, with modifications allowing of unusually high magnifying power and with good definition, and its employment in combination with a trough of fluid mercury.

Tested in this way, a vibration is undoubtedly perceived at times, and nowhere could we expect to be entirely free; for such a universal cause as the wind striking on the outside of a building would produce some degree of tremor in the subjacent soil. But the question here is, Does the vibration take place to such an extent as to vitiate the observations?

In answer to this I say, Certainly not; for during the last five years, the collimating apparatus has been in weekly, if not in daily, use with the transit instrument, and on no single occasion was there ever any impediment to accuracy of measure caused by vibration transmitted through the ground from any of the neighbouring roads or railroads;—though from the remarkable sensibility of the apparatus employed, the effects of the wind shaking the building, or persons walking about, in, and even immediately around it—circumstances not peculiar to the Calton Hill—have sometimes impeded the observations.

But inasmuch as on each day that the observations were made, they lasted only about twenty minutes, the theoretical shakers may possibly suggest, that chance had always hit on the times of no railway trains being on the move. Recently, therefore, I made a more crucial experiment, and in this manner:—

I stationed myself one day for three hours at the mural circle, to

which a very powerful collimating eyepiece has been applied, and, having the telescope pointed to the mercury trough, and the reflected wires in view, I noted carefully the times and the characters of any defalcations from good definition. Meanwhile the assistant astronomer had gone to the part of the railroad nearest to the Observatory with a chronometer, and noted the times of any trains passing, their speed, and the number of carriages. On his return, the lists of times being compared, it was found that *no* result had attended long trains moving slowly or short ones moving quickly, but that the *long* trains moving *quickly* had produced a barely sensible effect in spoiling somewhat of the definition of the reflected wires. Never had this disturbance, however, amounted to a quantity that need have prevented an observation being taken. In a word, the disturbance was practically quite unimportant, and this, with an apparatus so sensitive that a slight tapping with the hand on the great stone-pier, containing about 120 cubic feet, produced so great an effect as to render the wires for a time altogether invisible.

Moreover, by comparing the amount of railway vibration observed here, with that found at Greenwich and other observatories on loose and soft soils, we find it to be less than a third of what is experienced there. This result, so contrary to the usual belief of the facility with which rock conducts vibration, is perhaps attributable to the circumstance, that whatever vibration is produced in the hard, unyielding material, is very small, while that in the softer, looser soil, is very great and violent at the place. In the rock, the wave, such as it is, may travel quicker and farther, and with the characteristics of a high musical note, than one of the same initial size in gravel; but the wave produced in the gravel by the same disturbing cause appears to be so much larger at the place, as to be able to travel to a very great distance, though with a slower motion and a lower note (if any bo audible) than in rock, and to be felt to a greater extent within a certain range.

The whole result is thus highly satisfactory for the stability of the Edinburgh instruments; since we have not only, by reason of this rock foundation, an immunity from the prejudicial action of water penetrating the ground and heaving up the piers, but there is also such a decided lessening in the amount of vibration, and the disturbance of any optical image seen in the mercury.

3. On a General Method of effecting the substitution of

Iodine for Hydrogen in Organic Compounds, and on the properties of Iodo-Pyromeconic Acid. By Mr James Brown, assistant to Dr Thomas Anderson.

Following up his researches on pyromeconic acid, read before this Society in 1852, the author described a method which he had recently discovered, through his experiments on iodo-pyromeconic acid, of generally obtaining iodine substitution for hydrogen compounds.

The mere digesting pyromeconic acid with tincture of iodine was not successful; because, as the author considered, there was no body present, capable of drawing all the hydrogen in the compound to itself, and so leaving, as it were, an open space which the iodine might step into and occupy.

This requisition, however, he found to be perfectly complied with, by introducing with the iodine a certain quantity of either bromine or chlorine; and the mode which he preferred of producing the iodo-pyromeconic acid was, by mixing a freshly-prepared solution of chloride of iodine with a cold saturated solution of pyromeconic acid.

The resulting acid is monobasic, and forms salts, of which those of baryta of lead were described by the author at length.

The following Gentleman was elected an Ordinary Fellow:—

Henry Dunlop, Esq. of Craigton.

The following Donations to the Library were announced:—

Smithsonian Contributions to Knowledge. Vol. V. 4to.

Sixth Annual Report of the Board of Regents of the Smithsonian Institution for the year 1851. 8vo.

Smithsonian Institution Meteorological Tables. Prepared by Arnold Guyot. 8vo.

Portraits of North American Indians. With Sketches of Scenery, &c. Painted by J. M. Stanley. Deposited with the Smithsonian Institution. 8vo.

Catalogue of North American Reptiles in the Museum of the Smithsonian Institution. 8vo.—*From the Institution.*

Owen's Geological Survey of Wisconsin, Iowa, and Minnesota. With Illustrations. 4to.

Schoolcraft's History of the Indian Tribes of the United States. Part 3. 4to.

Memoirs and Maps of California. By Ringgold. 8vo.

Stansbury's Expedition to the Great Salt Lake. 8vo. With Maps.

Report on the Geology of the Lake Superior Land District. By J. W. Foster and J. D. Whitney. Part 2. 8vo. With Maps.

Official Report of the United States Expedition to explore the Dead Sea and the River Jordan. By Lieut. W. F. Lynch, U.S.N. 4to.—*From the American Government.*

Boston Journal of Natural History, containing Papers and Communications read before the Boston Society of Natural History. Vol. VI., Nos. 1 & 2. 8vo.—*From the Editors.*

Bulletin de la Société Imperiale des Naturalistes de Moscou. 1851, Nos. 3 & 4. 1852, No. 1. 8vo.—*From the Society.*

Bulletin de la Société de Géographie. 4ieme Série. Tomes IV. & V. 8vo.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1852, iii. Jahrgang. 1853, iv. Jahrgang. 8vo.—*From the Institute.*

Flora Batava. 173 Aflevering. 4to.—*From the King of Holland.*

Stellarum Fixarum imprimis duplicium et multiplicium positiones mediæ pro epocha 1830,0. Auctore F. G. W. Struve. Fol. —*From the Russian Government.*

Mémoire sur les Ouragans de la Mer des Indes, au sud de l'Equateur. Par M. A. Lefebre. 8vo.

Considérations générales sur l'Océan Pacifique pour faire suite à celles sur l'Océan Atlantique et sur l'Océan Indien. Par M. Charles P. de Kerhallet. 8vo.

Tableau général des Phares et Fanaux des Cotes de la Méditerranée, de la Mer Noire, et de la Mer d'Azof. 8vo.—*From the Depôt Général de la Marine.*

Abhandlungen der Mathemat. Physikalischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. Bd. VII., 1th Abth. 4to.—*From the Academy.*

Annalen der Königlichen Sternwarte bei München. V. Bd. 8vo.

Jahres Bericht der Münchener Sternwarte für 1852. 8vo.—*From the Observatory.*

Afrika vor den Entdeekungen der Portugiesen. Von Dr Friedrick Kuntsmann. 4to.—*From the Author.*

Studien des Göttingischen Vereins Bergmännischer Freunde. Im namen desselben herausgegeben von J. F. L. Hausmann. Bd. XVI. Heft. 1 & 2. 8vo.

Nachrichten von der Georg-Augusts Universität und der Königl. Gesellschaft der Wissenschaften zu Göttingen. 1852. 12mo. —*From the Society.*

Monday, 17*th April* 1854.

RIGHT REV. BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. On the Products of Destructive Distillation of Animal Substances. Part. III. By Dr Thomas Anderson.

2. Notice of the Completion of the Time-Ball Apparatus. By Professor C. Piazzi Smyth.

The electric time-ball, erected on the Calton Hill last October by the Government, and placed under the author's charge, has now been at work for five months. But the work has necessarily been of an experimental or tentative character; for before the accuracy of the signals could be guaranteed, it was necessary to have experience of the machinery in all weathers; and, moreover, the present strength of the Observatory establishment, and the nature of pre-existing occupations, prevented the experiments being made every day.

There have, however, been now upwards of 100 daily signals made, *four* only of which have proved defective, and from causes which have since been remedied, so that there is now strong warrant against future accidents.

In the course of the trial, the following questions presented themselves, and, if not answered satisfactorily by the experiments, suitable alterations were made in the machinery.

1*st*, Is the fall of the ball *equally* quick in windy as in calm weather?

The answer is, that it is so, owing to the great weight of the ball, something near a ton, overpowering any side pressure of the wind, while all other friction is carefully relieved.

2d, Is it sufficiently quick to make the commencement of the fall an accurate observation?

It is; for it falls through the first 4 feet in less than 0·3 of a second; and as a separation of the descending ball from the fixed cross staffs to the extent of 6 inches would be abundantly visible to observers all over the city, they should not err to more than one second.

3d, Is the impetus of this falling body sufficiently broken and quieted in fall, so as not to endanger the permanence of itself or the building?

The concussion is so completely broken by the cylinder of air which receives and bears up the piston connected with the ball, that the ball invariably comes to rest on its bed block without any sensible shock or sound.

4th, Is the dropping of so huge and cumbrous a weight as the ton-heavy ball managed by a trigger sufficiently delicate to insure exactness of manipulation, and sufficiently certain, as not to be thrown out by accidental causes?

This is the case to an eminent degree, through the introduction of a small auxiliary ball to do the labour of dropping the big one, so that it is only the trigger of the small one that has to be pulled by hand or by the electric force, and it has to be pulled with a force of but a few grains, and through about $\frac{1}{30}$th of an inch.

Excepting the variations of strength of a certain spring, depending apparently on temperature, and now compensated by adding weights each morning, no other inconvenience has been experienced. And the trigger has held its place firmly, even when during some of the violent gales in the winter, the top of the monument was rocking about to such an extent as to make the duty of attending to the ball somewhat unenviable.

5th, Is there any loss of time or accuracy by the ball being on Nelson's Monument, and not in the Observatory?

Practically, none; for the trigger is pulled, and the ball dropped by electro-magnets, which are instantaneously animated by the galvanic circuit being completed in the Observatory.

6th, Is there any guarantee or permanent record of the time at which the signal was, and must have been made?

There was not, as the ball was placed in my hands, for all the exactness depended on the skill of the person making the signal;

and, after it was made, nothing was left behind to shew when it was made. This has, however, lately been altered, and the circuit is now completed by a mean-time clock, which is compared every day with the transit clock, and adjusted to the true time; their comparisons being duly entered in a ledger on every occasion, shew incontestibly the limit of error of the clock, and thereby of the fall of the *ball each* day.

Referring to these entries, I find that, during the last fortnight, the correction of the clock at a quarter before one, were, on

April 3,	− 0·0	April 11,	+ 0·1
... 4,	− 0·1	... 12,	− 0·0
... 5,	− 0·0	... 13,	+ 0·2
... 6,	+ 0·1	... 14,	− 0·1
... 7,	+ 0·2	.. 15,	− 0·1
... 8,	− 0·1	... 17,	− 0·1
... 10,	− 0·0		

And as the greatest daily rate of the clock during this period was never more than 0·3 seconds, the above must have been sensibly the errors of the clock at one hour, and, therefore, of the drop of the ball, subject only to a constant correction for the time necessary for the electricity to pull the various triggers. I have not been able yet to observe this quantity in any but an indirect manner, but suspect that it is under 0·1 second.

7th, What is the accuracy of the approximate signals afforded by the half rise and the full rise of the ball at 5 minutes and at 2 minutes respectively before 1?

As the clock is also made to give a species of electric signal to the raiser of the ball, he may and should have the windlass in motion within 0·5 of a second of the even minute. But, inasmuch as the movement of the ball on the mast is very slow, by reason of the number of intervening wheels and pinions necessary to get up the requisite power, the ball will not be seen to move visibly to persons outside, until the crank has made several revolutions.

From a series of four months' excellent observations of the time ball by Sir T. Brisbane, it appears that, to him in St Andrew Square, the rises were seen on an average 2·5 seconds too late, with a probable error of about 3 seconds. While, from another series of two months' observations by Mr Swan, at a greater distance from the hill, as in Duke Street, the retardation, as might be expected,

was greater, or about 3·5, while the probable error was about the same. By using a telescope with a cross view, as he appears to have done lately, he has considerably reduced both quantities. But each person should determine the amount of retardation for himself, as depending upon his distance from the hill, peculiarity of observation, and other such causes. This done, and the quantity applied to one of the rises as a correction, will give a very near approximation to the error of the observer's watch, so that he will be fully prepared to observe the instant of the *drop* to the utmost exactness.

8. Has the accuracy of the drop of the ball been independently tested?

As to absolute time, not that I am aware of; but as to relative time, it has by the two very careful series of observations already mentioned, by Sir T. M. Brisbane and Mr Swan. The results of these are given below in the rates of their chronometers, for similar days. And it will be observed, that although one of them did alter its rate somewhat irregularly backwards and forwards, still as the other was going on in a uniform march at the selfsame time, the anomalous effect was all owing to the one chronometer, and nothing sensible was due to any error of the time-ball.

In conclusion, the author observed that the arrangements which were in the course of being made, would give uninterrupted facility to the public for ascending to the top of the monument.

3. On a Black Tertiary Deposit, containing the Exuviæ of Diatomes, from Glen Shira. By Dr Gregory.

4. Additional Note to a Paper on the Structure of Coal, and the Torbanehill Mineral. By Dr Bennett.

5. On the Mechanical Energies of the Solar System. By Professor William Thomson.

In this paper it is shown, that by the sun's heat there is an emission of mechanical energy from the solar system, amounting in about 100 years to as much as the whole energy of the motions of all the planets. The principal object of the paper is to investigate the source from which this vast development of energy is drawn. It is argued, that either a store of primitive heat must be drawn upon,

or heat must be generated by chemical action (combustion), or heat must be generated by other forces than those of chemical action, that is, by forces of moving masses. Any store of primitive heat that can be drawn upon in solar radiation, must be entirely within the sun. It is shown that such a store would *almost certainly* be insufficient for the supply of the heat which has *certainly* been emitted during 6000 years, and it is also shown with about equally strong probability, that chemical action among elements of the sun's mass, would be insufficient to supply the actual emission for any such period of time. It is concluded that the source drawn upon in solar radiation cannot be primitive heat, nor heat of intrinsic combustion. If not heat of combustion at all, it must clearly be heat derived from the motion of bodies coming to the sun (the utter insufficiency, in point of duration, of ordinary motions of matter within the sun, being quite obvious); or if it be heat of combustion, fuel must be supplied from without. But no matter can come to the sun from external space, without generating, from its motion alone, thousands of times as much heat as it could possibly give rise to either by combustion among elements of its own, or by combination with substances primitively in the sun, unless it were possessed of incomparably greater chemical affinities than any known terrestrial or meteoric substance. It is inferred that the source of solar heat must be meteoric, and is *the motion of meteors coming to the sun.* The idea that solar heat is so produced, appears to have been first published by Mr Waterston, who brought it forward at the late meeting of the British Association at Hull.

But if (as was assumed by Mr Waterston) enough of meteors to generate heat at the actual rate of solar radiation, were falling in from extra-planetary space, the earth in crossing their path, would be struck much more copiously by meteors than there is any probability it is; and the increase of matter round the centre of the system, would within the last two or three thousand years, have caused an acceleration of the earth's motion, which history disproves. Hence the meteors which supply the sun with heat must, at least during historical periods, have been within the earth's orbit. We see them there in the sunshine (when the sun himself is below our horizon) a tornado of dust, called "the Zodiacal Light" whirling round the sun and carrying the inter-planetary atmosphere with them, probably to such an extent, as to cause centrifugal force

enough very nearly to balance solar gravitation upon it everywhere, except close to the sun's surface. The meteors themselves probably evaporate somewhere near the sun, merely on account of the high temperature of that part of space, but ultimately losing their rotatory motion by intense resistance in entering the sun's atmosphere, become condensed into a liquid state by solar gravitation, and come to rest in the sun. The quantity of heat thus generated in the region of intense resistance, by any quantity of matter falling in, will exceed half the equivalent of the work done by solar gravitation on an equal mass moving from an infinite distance by (what must probably be quite insensible in comparison) the latent heat evolved in condensation, together with the heat of any chemical combination that may take place. The other half of the work done by solar gravitation on every meteor which has come from an infinite distance (or from many times the sun's radius off), goes to generate heat in inter-planetary air by friction.

The meteoric matter thus added to the sun, to generate heat at the present rate of emission as determined by Pouillet, if settling at the surface with the same as his mean density, would cover it about sixty feet thick in a year, and would not increase his apparent dimensions by more than about 1″ in 40,000 years; or in 2,000,000 years, by as much as he appears to grow from July to December. It must, therefore (whatever be the actual density of the deposit), be insensible from the earliest historical period of observation till the present time; and for thousands of years to come, if continued only at the same rate, it must remain neither demonstrated nor disproved by the most accurate measurements of the sun's apparent magnitude.

The approximate equality of solar heat in all regions of his surface is probably due to the distillation of the meteors, which if solid when entering the region of intense resistance, would probably give an immensely more copious supply in the equatorial than in the polar regions. The dark spots are probably whirlwinds, analogous to the hurricanes in the tropical regions of the earth's atmosphere, (although produced by a different cause,*) which by centrifugal

* The friction of the vortices of meteoric vapour close round the sun, upon the atmosphere between them, and his surface revolving at the comparatively slow rate of once in twenty-five days, probably gives rise to eddies sometimes

force diminish very much for a time the deposit of meteoric matter on limited portions of the sun's surface, and allow them to cool by radiation so much, as to become comparatively black.

The following Gentlemen were elected as Ordinary Fellows :—

1. Dr William Bird Herapath.
2. Robert Harkness, Esq., Professor of Mineralogy and Geology, Queen's College, Cork.
3. Dr Thomas A. Wise, H.E.I.C.S.

Monday, 1st May 1854.

Right Rev. BISHOP TERROT, V.P., in the Chair.

The following Communications were read :—

1. Further Researches on the Crystalline Constituents of Opium. By Dr Thomas Anderson.

2. On the Action of the Halogen Compounds of Ethyl and Amyl on some Vegetable Alkaloids. By Mr Henry How, Assistant to Professor Anderson of Glasgow.

This paper contains some details of a continued investigation, of which the first results were communicated to the Chemical Society of London last year.* It was then shown that new bases are produced by the action of iodide of methyl and of ethyl upon morphia and codeine, which are closely analogous with the ammonium bases of Hofmann, so that these alkaloids should rank among nitryle bases. The fact was also pointed out, that although one of the new salts produced had precisely the centesimal composition of the corresponding compound of codeine, the base of the artificial product was widely different from this alkaloid; and the conclusion was drawn that the primary molecules of these natural formations are of so peculiar a constitution, that chemists are not yet in the possession of means of imitating the process of their construction; for even the attempt

reaching down to the sun's surface, and constituting hurricanes, which would probably have a progressive motion northwards on one side, and southwards on the other side of his equator.

* Quart. Jour. Chem. Soc., vol. vi.

to convert morphia into codeine fails, though the addition of the requisite amount of carbon and hydrogen to the former is readily effected. It was further remarked that the circumstance of both these alkaloids furnishing the same results, under the given circumstances, possibly arose from their similar origin; and that it was intended to examine other alkaloids of opium, and some from other sources, in the same way. In the present memoir it is shown that attempts to produce ammonium bases from other alkaloids of opium have not been successful; but this result has been obtained from strychnine, and the new products have admitted of more detailed examination, from their possessing a more stable nature than the analogous derivatives from morphia and codeine.

Behaviour of Papaverine with Iodide of Ethyl.

Hydriodate of Papaverine.—The next base from opium submitted to trial was papaverine, an alkaloid of well-marked characters, and the subject of some recent researches of Dr T. Anderson.* It was found that, by heating some of this substance in a sealed tube with spirit of wine and iodide of ethyl, it is converted into an hydriodate with great ease. The salt proved to be that of the unchanged alkaloid, of the formula,

$$C_{40}\ H_{21}\ NO_8,\ HI.$$

It is extremely soluble in water, and the moment the heat is withdrawn from a strong solution, the fluid becomes milky, and an oil is deposited, which assumes a crystalline solid form in the course of a few hours. It is unaltered in the air, but decomposed, at least partially, at 212° Fahr.

All doubt as to the nature of the base in this salt was removed by its analysis when set free, by the action of ammonia on the hydriodate. The white crystalline deposit so obtained, gave, after one crystallization from dilute spirit, analytical results perfectly in accordance with the formula,

$$C_{40}\ H_{21}\ NO_8\,;$$

which is that of papaverine. Its reactions were also identical with those characteristic of the alkaloid.

Narcotine and Iodide of Ethyl.

Hydriodate of Narcotine.—This opium base behaved exactly like

* Trans. Roy. Soc. Edin., vol. xxi., part i.

the preceding; the hydriodate of narcotine resulting from the action was an oily substance of a brownish colour, which could not be made to crystallize; it was soluble in hot water, and ammonia threw down from this solution a precipitate easily recognised as narcotine; its nature was fully substantiated by the quantitative analysis of its platinum compound, which gave results agreeing with the salt of narcotine, whose formula is this,

$$C_{46} H_{25} NO_{14} H Cl, Pt Cl_2.$$

The result of this experiment calls to mind a preliminary notice of Wertheim,* in which he announced his detection in opium of two new species of "narcotine," which he terms methylo and propylo-narcotine, while the ordinary alkaloid he regards as ethylo-narcotine. The proof of the existence of this series is desirable, because the ordinary alkaloid, the material of the above experiment, would then seem to be a compound ammonium, and stand a solitary instance of such a substance, unless papaverine be of the same nature. The details of Wertheim's researches have not appeared, but the subject is worthy of being made clear, as there is nothing in the characters of papaverine and narcotine to distinguish them from other alkaloids as a class of bodies.

Cotarnine and Iodide of Ethyl.

Hydriodate of Cotarnine.—This base, a derivative from narcotine by oxidation, behaved quite like its parent under the same circumstances. The hydriodate of cotarnine is a red-brown oil, very soluble in hot, insoluble in cold, water; the nature of its base was ascertained by the formation of its platinum salt, which was a pale yellow substance, and gave numbers on analysis in accordance with the true salt of cotarnine,

$$C_{26} H_{13} NO_6 H Cl, Pt Cl_2.$$

The formation of these hydriodates in the presence of water is possibly brought about by the change of iodide of ethyl and water into hydriodic acid and ether, observed by Frankland† to take place at 300° Fahr.; the presence of bases may determine the change at a much lower temperature.

Where water is absent, it is not easy to see how they are formed,

* Chem. Gazette, 1852, p. 36. † Gerhardt. Suite de Berzelius, ii., 323.

unless ether be produced at the same time from the alcohol used as a solvent; for instance with papaverine, thus—

$$C_{40}H_{21}NO_8 + C_4H_6O_2 + C_4H_5I = C_{40}H_{21}NO_8, HI + 2C_4H_5O.$$

On Strychnine.

This alkaloid, as being one of those which contain two atoms of nitrogen, was considered an interesting object for examination. Numerous speculations have been gone into as to the mode in which this element exists in such substances, before the experiments of Hofmann gave a point of comparison between ammonia and other basic bodies. These are now regarded, viewed from the volatile type upwards, as nitrogen attached to basic hydrogen alone, or to it with hydrocarbons, or finally to hydrocarbons alone, occupying all its place. In the fixed vegetable alkaloids oxygen is included in the system, and here oxygenized hydrocarbons must act as hydrogen, if, as has been attempted to be shown in a former paper on this subject, these bodies are comparable with nitryle bases. In the case of one of these containing two atoms of nitrogen, it is possible that this element performs, as it were, two parts; one being referable to its function in any simple nitrogenous base, while the other may be more analogous to its property when combined with oxygen as NO_4, of replacing hydrogen in the carbohydrogen of the molecule—a speculative suggestion thrown out some few years ago by Fresenius.

This question it is attempted to decide by means of two classes of reagents; the amount of basic hydrogen in strychnine should be ascertained by the action of iodide of ethyl, &c., while any oxidized compound of nitrogen, as NO_4, should be reduced by sulphuretted hydrogen, and hydrogen added while oxygen is removed.

The former part of the subject is gone into in some detail in this paper, while mention is made that strychnine undergoes a curious change with sulphide of ammonium, resulting in the production of hyposulphite of the base, a stable and beautiful salt, and some other product as yet imperfectly studied; from what is at present known, however, it is thought that the change is not of the nature above spoken of.

Action of Iodide of Ethyl on Strychnine.

Hydriodate of Ethylostrychnine.—Strychnine in fine powder is readily attacked by iodide of ethyl, even partially in boiling water;

the insolubility of the base in this menstruum renders spirit a better medium, and the best method of bringing about the reaction was found to be by operations in sealed tubes. At the temperature of 212° Fahr. the change is effected in twenty minutes, and this is announced by the complete solubility of the crystalline contents of the tube in boiling water. The new salt proved to have the formula of hydriodate of strychnine, in which an atom of hydrogen of the base is replaced by ethyl, or in which an atom of ethyl is attached to it considered as an iodide, formed thus :—

$$\underbrace{C_{42}H_{22}N_2O_4}_{\text{Strychnine.}} + C_4H_5I = \underbrace{C_{42}\left\{\begin{matrix}H_{21}\\C_4H_5\end{matrix}\right\}N_2O_4, HI = C_{46}H_{27}N_2O_4, I.}_{\text{New Salt.}}$$

It is soluble in about 50 or 60 parts boiling water, and in about 170 parts at 60°; and is deposited from tolerably dilute fluids in fine, white, four-sided prisms; it is unaltered in the air, and at 212°.

It yields no base to potass or ammonia, but is precipitated unchanged from its aqueous solution in the cold by the former, more immediately in the heat by the latter. Oxide of silver readily eliminates its iodine, and leaves the base in solution, from which it may be obtained in the crystalline state as a hydrate. These reactions assimilate the salt to an iodide, and the salts of the base are accordingly named in accordance, but the conventional nomenclature of the base is not altered. Some of these salts are described and their analysis is given in some cases; they are spoken of as being beautiful substances, and easily obtained pure.

Nitrate of Ethylostrychnine.—This is a compound of such sparing solubility in cold water, that it has served as a test for the base. From dilute hot aqueous solutions it is deposited in colourless refractive prisms of great beauty, which are anhydrous, and have the formula,

$$C_{46}H_{26}N_2O_4, HO, NO_5 = C_{46}H_{27}N_2O_4, NO_6.$$

Chromates of Ethylostrychnine.—A neutral and an acid salt exist, both of difficult solubility in cold water, and of a yellow colour; the former is deposited even from dilute fluids in short prismatic crystals, and the latter as tufts of silky needles.

Bichromate of Ethylostrychnine.—From strong solutions this salt

is deposited in splendid transparent plates, of a golden yellow colour; it has the composition, when dried at 212° F.,

$$C_{46} H_{26} N_2 O_4 HO Cr O_3, HO Cr O_3 = C_{46} H_{27} N_2 O_4 Cr O_4, H Cr O_4,$$

and is thus seen to differ from the peculiar combinations of potass and ammonia, by containing an atom of water more than these salts have. This anomaly may be explained away by the assumption that this atom is retained from the water of crystallization, of which the new salt contains in addition two atoms; its formula being, air dry,

$$C_{46} H_{27} N_2 O_4 Cr O_4, H Cr O_4 + 2 aq.$$

Platinum Salt of Ethylostrychnine.—This compound falls at first as a curdy yellow precipitate, which becomes crystalline on standing; from dilute fluids it crystallizes at once in a very beautiful form, viz., in stellate groups of fern-frond-like crystals: it is anhydrous, and has the formula,

$$C_{46} H_{27} N_2 O_4 Cl, Pt Cl_2.$$

The corresponding gold salt crystallizes from water in colourless brilliant prisms, of splendid appearance.

The chloride is a very soluble salt, crystallizing in needles; the sulphate and oxalate crystallize from acid solutions in pearly needles; the acetate is an amorphous gum in the dry state. The chloride gives a crystalline double salt with mercuric chloride.

Carbonates of Ethylostrychnine.—The tendency of the base in aqueous solution to absorb carbonic acid being observed, the attempt to procure carbonates was made, and there exist two; but the monocarbonate cannot be obtained dry, as in the process of evaporation it decomposes into some basic product and impure bicarbonate—a salt which may be produced not only of constant composition, but as a beautiful crystalline substance.

The monocarbonate is readily produced by double decomposition between the iodide of ethylostrychnine and moist carbonate of silver. A few minutes contact suffices to effect the change, the solution of the carbonate is found to decompose on simple evaporation either *in vacuo* or at 212°, into impure bicarbonate, and a substance, insoluble in water, which has the characters of a base, quite distinct from strychnine or ethylostrychnine; but material was wanting to establish its nature thoroughly.

Bicarbonate of Ethylostrychnine.—This salt is formed by passing a stream of carbonic acid gas into a freshly prepared solution of the

simple carbonate: it admits of preparation in the dry state, either at 212°, or *in vacuo*; its solution undergoing in a very slight degree the decomposition just mentioned. Prepared by these means it is a crystalline mass, which is completely soluble in alcohol, and is thrown down in very fine prismatic crystals, by ether added in small quantity to this solution. It is not deliquescent, but is very soluble in cold water; its reaction is strongly alkaline. Its composition is shown by analysis to be, as expressed in the formula,

$$C_{46}\,H_{26}\,N_2\,O_4\,HO\,CO_2,\,HO\,CO_2 = C_{47}\,H_{27}\,N_2\,O_4\,CO_3,\,H\,CO_3$$

quite analogous to the corresponding salt of potass.

In repeating some experiments mentioned in Liebig's Traité,* it was found that the statement there made as to the existence of a solid carbonate of strychnine is erroneous; nor could carbonates of morphia, codeine, papaverine, or narcotine be obtained.

The notice of Langlois† having succeeded in forming carbonate of quinine arrested the intended extension of these trials with other alkaloids.

Hydrate of Ethylostrychnine.—When moist oxide of silver is added to the solid iodide, a strongly alkaline fluid of a rich purple colour is obtained which yields on evaporation *in vacuo* a crystalline residue, containing some little carbonic acid. This is completely soluble in absolute alcohol, and ether added to the fluid with certain precautions, occasions the deposition of a substance in beautiful small colourless needles, which prove on analysis to be the hydrated ethylostrychnine, or oxide of ethylostrychnium, of the formula,

$$C_{46}\,H_{27}\,N_2\,O_4\,O,\,HO + 3\,aq.;$$

it differs from its assumed analogue, the crystallized hydrate of potass, in containing an atom less of water.

The substance cannot be freed of its water by heat, as its aqueous solution is found, by evaporation at 212°, to undergo the same change as the monocarbonate, and also to absorb carbonic acid to some extent. It is not deliquescent, its aqueous solution has a red purple colour, and an extremely bitter taste; it precipitates barium and calcium solutions partially in the heat, and the heavy metallic oxides at once from their salts. It yields products by the action of chlorine,

* Liebig. Traité de Chimie Organique, par Gerhardt, ii. p. 630.

† Chem. Gazette, 1853, p. 470.

iodine, and bromine. By treatment with sulphide of hydrogen it and its carbonate are converted into hyposulphite of some sort, which may be crystallized from alcohol. It gives the same reaction with bichromate of potass and sulphuric acid as strychnine.

When iodide of ethylostrychnine is distilled with soda-lime, a non-basic oil, and a base insoluble in water, are obtained, but material was wanting to prove whether the latter is leucoline or ethyloleucoline. The solution of the hydrate itself evolves the odour of a volatile base on ebullition.

Action of Iodide of Ethyl on Ethylostrychnine.

When a solution of the hydrate in absolute alcohol is heated with iodide of ethyl in a sealed tube, iodide of ethylostrychnine is reproduced, accompanied by some secondary product, which appears to modify its characters to some degree.

Action of Chloride of Amyl on Strychnine.

Chloride of Amylostrychnine.—By protracted boiling of the alkaloid with absolute alcohol and chloride of amyl in a sealed tube it was completely changed. The new salt was obtained by distilling off the excess of spirit and reagent as a crystalline mass, which was completely and readily soluble in warm water. In the crystals from water, the salt was found to have the composition expressed in the formula,—

$$C_{52}\,H_{33}\,N_2\,O_4\,Cl,\,HO\ +\ 7\ aq.$$

At a temperature of 212° Fahr, the 7 aq. are expelled, and the dried compound is—

$$C_{52}\,H_{33}\,N_2\,O_4\,Cl,\,HO.$$

Its characters are generally analogous to the corresponding salt of the ethyl base. It is of greater solubility in water and in spirit. Its decomposition by heat is attended by the final production of fumes of a most disgusting odour.

In contact with ammonia, it appears to undergo some decomposition; in the cold, long contact produces a crystalline substance, having the qualitative characters of strychnine; the reproduction of this alkaloid, and the formation of amylamine, appears possible under the circumstances, as in the equation,

$$C_{52}\,H_{33}\,N_2\,O_4\,Cl + NH_3 = C_{42}\,H_{22}\,N_2\,O_4\ +\ C_{10}\,H_{13}\,N,\,HCl;$$

but the proof of this decomposition was not attained, as much of the original salt remained unchanged.

With strong ammonia in a heated sealed tube, a more complex change appears to take place; but its nature was also not made out.

Chloride of ethylostrychnine also yields a small crystalline deposit when left in contact with ammonia for some days.

Nitrate of Amylostrychnine.—This is a beautiful salt, crystallizing from water in groups of colourless prisms, which have the composition,

$$C_{52} H_{33} N_2 O_4 NO_6, HO, + 10 \text{ aq.};$$

the salt is not obtained anhydrous at 212°, but when so dried, is

$$C_{52} H_{33} N_2 O_4 NO_6, HO;$$

it furnishes a crystalline double salt with mercurous nitrate.

Bichromate of Amylostrychnine.—This is a yellow crystalline salt, difficultly soluble in cold water; when dried at 212°, it is found to have the composition,

$$C_{52} H_{33} N_2 O_4 CrO_4, H Cr O_4,$$

analogous to the corresponding compound of the ethyl base.

Chloride of amylostrychnine, when treated with oxide of silver, yields an alkaline purple solution, which agrees in properties with solution of ethylostrychnine, and leaves, on evaporation *in vacuo*, a crystalline residue, whose characters are so like that left by the other that there can be little doubt the crystals obtained by use of alcohol and ether are the hydrate of amylostrychnine, having a composition closely corresponding with the ethyl product.

It is hoped to clear up, in a future paper, some of the points touched upon in the present, and the following inferences are drawn from the facts brought forward:—

That the new basic compounds, ethylo and amylo strychnine, are analogous to Hofmann's ammonium bases, and quite distinct from the natural alkaloids.

That the already complex molecule of the vegetable alkaloid is rendered more susceptible of change by association with additional hydrocarbons.

That strychnine appears to be made up of a complicated molecule in which the one atom of nitrogen, as in ammonia, is associated with a nitrogenous aggregate of elements, whose function is that of three atoms of hydrogen, and whose nitrogen is in some distinct form of

combination, as yet undetermined, from that of the first, generic atom,—a composition attempted to be expressed thus:—

$$C_{42}H_{22}N_2O_4 = \left\{ C_{42}H_{22}NO_4 = \left\{ \begin{matrix} H \\ H \\ H \end{matrix} \right\} N \right\}$$

And the appropriation of an alcohol hydrocarbon by this molecule causes the production of an ammonium congener, which, in combination with some electro-negative element, may be thus written:—

$$C_{42}H_{22}NO_4 = \left. \begin{matrix} H \\ H \\ H \\ C_nH_{(n+1)} \end{matrix} \right\} N + X.$$

In conclusion, a tabular statement is made of the products analysed in course of the investigation, with the termination *ium* for the bases, in analogy with ammonium:—

Hydriodate of papaverine		$C_{40}H_{21}NO_8HI$
Iodide of ethylo-strychnium		$C_{46}H_{27}N_2O_4I$
Hydrated oxide of	do. crystallized	$C_{46}H_{27}N_2O_4O, HO, + 3$ aq.
Nitrate of	do. ...	$C_{46}H_{27}N_2O_4NO_6$
Bichromate	do. dried at 212°	$C_{46}H_{27}N_2O_4CrO_4, HCrO_4$
Do.	do. crystallized	$C_{46}H_{27}N_2O_4CrO_4, HCrO_4 + 2$ aq.
Platinum salt	do. ...	$C_{46}H_{27}N_2O_4Cl, PtCl_2$
Bicarbonate do.	do. dry	$C_{46}H_{27}N_2O_4CO_3, HCO_3$
Chloride of amylo-strychnium	dried at 212°	$C_{52}H_{33}N_2O_4Cl, HO$
Do.	do. crystallized	$C_{52}H_{33}N_2O_4Cl, HO + 7$ aq.
Nitrate of oxide	do. dried at 212°	$C_{52}H_{33}N_2O_4NO_6, HO$
Do.	do. crystallized	$C_{52}H_{33}N_2O_4NO_6, HO + 10$ aq.
Bichromate	do. dried at 212°	$C_{52}H_{33}N_2O_4CrO_4, HCrO_4$.

3. On the Mechanical Value of a Cubic Mile of Sunlight, and on the possible density of the Luminiferous Medium. By Professor William Thomson.

The velocity of light being 192,000 miles per second, and the mechanical value of sunlight incident perpendicularly on a square

mile at the earth's distance being $83 \times 5280 \times 5280$ foot pounds; the mechanical value of all the energy potential and actual, kept up in the space of a cubic mile by sunlight crossing it, is $\frac{83 \times 5280 \times 5280}{192,000}$ $= 1200$ ft. lbs. at the earth's distance. Similarly the mechanical value of a cubic mile of sunlight near the sun is found to be $1200 \times 46,000 = 55,000,000$ foot pounds.

If A be the excursion on each side of its position of equilibrium, which any particle would have if the mean effect of the solar radiation at the earth's distance were produced by plane polarised vibrations of wave length λ, the mass of a cubic foot of the luminiferous medium, in pounds, is shown to be

$$\frac{g \times 83}{2\pi^2 \times V^3}\left(\frac{\lambda}{A}\right)^2 = \frac{\left(\frac{\lambda}{A}\right)^2}{77 \times 10^{23}}$$

where g is the number 32·2, measuring the force of gravity, and V the velocity of light in feet per second. Similarly, if A and λ relate to sunlight near the sun, the mass of a cubic foot of the vibrating medium in that locality is found to be

$$\frac{\left(\frac{\lambda}{A}\right)^2}{166 \times 10^{18}}$$

The possibility of great variation in density of the luminiferous medium at different distances from the sun, depending on solar gravitation, and heat, and centrifugal force of the vortices kept up in it by planetary and meteoric motions, is indicated; and it is suggested that a refraction of this inter-planetary atmosphere may produce annual apparent motions in the stars, which may be sensible, although not yet discovered.—As to the preceding expressions for the density of the vibrating medium, all that is known of the values of $\frac{\lambda}{A}$ is that they must in all probability be large. If nothing less than 100 be admissible, the mass of a cubic foot of the vibrating medium at the earth's distance could not be less than

$$\frac{1 \text{ lb.}}{77 \times 10^{19}}$$

and near the sun it could be no less than

$$\frac{1 \text{ lb.}}{17 \times 10^{15}}$$

If the earth's velocity (being about $\frac{1}{10000}$ of the velocity of light) be admitted as not too great for the maximum velocity of vibration of plane polarized light, the mass of the luminiferous medium within a sphere concentric with the sun, with radius equal to that of the earth's orbit, might be not more than $\frac{1}{1200}$ of the earth's mass, since the mechanical value of light within that space is about $\frac{1}{1200}$ of that of the earth's motion.

4. Account of Experimental Investigations to answer questions originating in the Mechanical Theory of Thermo-Electric Currents. By Professor W. Thomson.

In this communication the mode of experimenting was described by which the experimental results quoted in the theoretical paper were obtained; and the principal parts of the special apparatus which had been constructed and used in the investigation, were laid before the Royal Society.

5. Dynamical Theory of Heat, Part VI. continued. A Mechanical Theory of Thermo-electric Currents in Crystalline Solids. By Professor W. Thomson.

In this paper the Mechanical Theory of Thermo-electric Currents in linear conductors of non-crystalline substance, first communicated to the Royal Society December 15, 1851, is extended to solids of any form and of crystaline substance.

It is first proved, that if a solid be such that bars cut from it in different directions have different thermo-electric powers relatively to one another, or to other linear conductors, forming part of a circuit, there must, for every bar cut from it, except in certain particular directions (principal thermo-electric axes), be a new thermo-electric quality, of a kind quite distinct from any hitherto known; giving rise to a reciprocal thermo-dynamic action, which consists of *a difference in temperature at the sides of the bar causing a current to flow longitudinally, when the two ends, being at the same temperature, are connected by a uniformly heated conductor; and a current through the bar causing an absorption and evolution of heat at its two sides, when these are kept at the same temperature.*

The most general conceivable thermo-electric relations of a crystalline solid, or body possessing, inductively or structurally, different physical properties in different directions, are next examined. It is shown how a metallic structure may be actually made up of pieces of different non-crystalline metals, which, taken on a large scale compared with the dimensions of the heterogeneous elements of which it is composed, will be found to exhibit the most general type of thermo-electric directional relations indicated by the abstract investigation; and it is inferred that it would be wrong to limit the general expressions by any particular assumption, even if we only discover simpler types of thermo-electric relations in natural crystals.

The general equations determining the thermo-electric currents in any naturally, inductively, or structurally crystalline solid; resulting either from a completely specified distribution of temperature through it; or from given external appliances of heat, on which, and on the thermo-electric currents themselves, the distribution of heat through the interior will depend; are investigated.

Certain particular applications of the general equations are also made; and the thermo-electric properties of metallic structures (laid before the Society as solids actually possessing the properties referred to), are investigated.

The paper in which this extension of the theory is described, includes a more developed account of the theory of thermo-electric currents in non-crystalline conductors, formerly communicated, than has been hitherto printed; with a simplification in the fundamental equations introduced without hypothesis, by the adoption of a thermometric assumption proposed as the foundation of an absolute scale of temperature, in consequence of thermo-dynamic experiments on air recently made by Mr Joule and the author. It also includes a brief outline of some experimental investigations undertaken to answer questions proposed in the former theoretical communication, and suggested by various considerations which occurred in the course of the research, and by the new part of the theory now communicated to the Royal Society.

7. On the Structure of Diatomacea. By E. W. Dallas, Esq.

The author directed attention to the following list of species, which, although imperfect, exhibits great variety in the forms, shewing the Medway to be very fertile in these organisms:

Epithemia Musculus.
Campylodiscus cribrosus.
Surirella striatula.
„ linearis.
Tryblionella marginata.
Tryblionella Scutellum.
„ punctata.
„ gracilis.
„ acuminata.
Cymatopleura elliptica.
Triceratium Favus.
„ striolatum.
„ undulatum.
Cyclotella Kutzingiana.
„ operculata.
And three species undetermined.
Actinocydus undulatus.
Actinoptychus senarius.
„ septenarius.
„ octonarius.
„ nonarius.
Eupodiscus Argus, 2 vars.
„ radiatus.
„ maculatus.
Coscinodiscus radiatus.
„ minor.
„ eccentricus.
„ Thwaitesii.
And an undetermined species.
Cocconeis Pediculus.
„ Scutellum.
Nitzschia sigmoidea.
„ dubia.
„ reversa.
And an undetermined species.
Navicula elliptica.
Navicula convexa.
„ Westii (?)
„ didyma,
„ pusilla.
„ punctulata.
„ palpebralis.
Pinnularia divergens.
Stauroneis pulchella.
Cocconema parvum.
Pleurosigma balticum.
„ Hippocampus.
„ angulatum.
„ acuminatum.
„ distortum.
Doryphora Amphiceros, vars.
„ Boeckii.
Achnanthes brevipes.
Grammatophora marina (?)
Biddulphia aurita.
Zygoceros rhombus.
Denticella sp.
Orthoseira sp.
Dictyocha.
Bacteriastrum furcatum (?)
„ curvatum (?)

Some of the species in this list have been described as new to Britain by Mr Roper, in a late paper published in the Microscopical Journal. The Coscinodiscus, not named, seems from the description to be the same with that found at the mouth of the Thames, and is an exceedingly beautiful disc. The four species of Actinoptychus are those described by Ehrenberg, and are new British species. They exhibit the strong siliceous cellular tissue underneath the moniliform structure of the surface, as in Actinocyclus. The examples of Triceratium striolatum, and also Zygocerus rhombus, differed somewhat from the figures and descriptions given of them, being provided with spines along the side, and with two spines placed close to the projecting terminations or angles of the valve, and which were always present in the examples that had come under observation. The surfaces of the valves were also seen to be dotted over with small nodules, giving them a very remarkable appearance, and which might be seen to project from the surface when the valve was suitably placed; these appearances might be attributable to a more mature developing of the siliceous structure.

Among the remarkable forms found, although not considered to belong to the Diatomaceæ, are the two varieties of Bacteriastrum, the discs of which, it may be observed, were three or four times the diameter of those described by Mr Shadbolt, from Port Natal, and the radiations more numerous.

Attention was directed to the structure of the Diatomaceæ as affording some of the most beautiful examples of geometric arrangement with which we are acquainted. It was pointed out that there are only three of the regular polygons that can be employed alone to fill up the space about a point in a plane surface, namely, the equilateral triangle, the square, and the hexagon; these forms and their angles are accordingly found to prevail in the structure of the tissues. By constructing the polygons, it was shewn that they arranged themselves in straight lines, determined by the shorter axis of the figures, the quadrilaterals having two directions in which the lines run, and the hexagons three. With the hexagonal structure, when one set of the lines passing through the axis is referred to a centre, the cells then appear to radiate in straight lines from the centre, while the other two directions in which they appear to run will be spiral lines, having a definite character according to the size of the cells. Much of the character of the tissue depends on the position of the axis of the polygon with respect to an axis of the valve,—that is, whether the longer or shorter axis is parallel to it. Mr Smith in his Synopsis has noticed this peculiarity, and in accordance with it has divided his genus Pleurosigma into two sections.

The above arrangements will be found to prevail in the structures of the tissues of the valves, and the influence of the living principle might generally be seen in the repetition of like spaces about a centre in each species, and always in the same numerical relations in each individual of the species, multiples of the numbers 2, 3, and 5, and also 7, seeming to prevail.

These divisions are seen very conspicuously in Actinocyclus and Actinoptychus. In the large species of Coscinodiscus, the number of sectors appeared to be twelve, from the groups of rows at the centre, and in it was shewn the very beautiful arrangement of the cells in radiating and intersecting spiral lines. Eupodiscus Ralfsii was referred to as affording an example of the division of the circle into sectors, within which the lines of cells are arranged symmetrically on each side of a single radiating row, to which the rest are

all parallel. In Eupodiscus maculatus, the disc is divided into ten, but the rows of cells do not converge towards the centre, except one at the side of each sector, to which the others are parallel. From this may be derived the very beautiful and peculiar construction of the Coscinodiscus eccentricus, in which the disc is divided into seven sectors, the rows of cells extending across the valve from each sector to meet similar rows from the second sector beyond.

The following Donations to the Library were announced:—

Archives du Muséum d'Histoire Nàturelle. Publiées par les Professeurs de cet établissement. Tome VII., Liv. 1 & 2. 4to. —*From the Museum.*

Actuarial Tables; Carlisle Three-per-Cent. Single Lives and Single Deaths. With Auxiliary Tables. By William Thomas Thomson, F.R.S.E., F.I.A. 4to.—*From the Author.*

On the application of Cast and Wrought Iron for Building Purposes. By William Fairbairn, C.E. 8vo.—*From the Author.*

Jahrbuch der Kaiserlich Königlichen Geologischen Reichsanstalt. 1853. IV. Jahrgang. 8vo.—*From the Institute.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Band VI. 4to.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Band XI. 8vo. —*From the Academy.*

Mémoires de l'Académie des Sciences de l'Institut de France. Tome XXIV. 4to.—*From the Academy.*

Memoirs of the Geological Survey of the United Kingdom. British Organic Remains. Parts 1, 2, 3, 4, 6, 7. 4to.

Memoirs of the Geological Survey of Great Britain, and of the Museum of Practical Geology in London. Vol. II. Pts. 1 & 2. 8vo.

Museum of Practical Geology and Geological Survey. Records of the School of Mines and of Science applied to the Arts. Parts 1, 2, 3, 4. 8vo. (With various Maps and Pamphlets.) —*From H. M. Government.*

Journal of the Geological Society of Dublin. Vol. VI., Part 1. 8vo.—*From the Society.*

The Assurance Magazine, and Journal of the Institute of Actuaries. Vol. IV., Part 3. 8vo.—*From the Institute.*

The American Journal of Science and Arts. Vol. XVII., No. 50. 8vo.—*From the Editors.*

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Mai 1853–Mai 1854. 4to.—*From the Academy.*

Memorie della Reale Accademia delle Scienze di Torino. Tom. XIII. 4to.—*From the Academy.*

Bulletins de la Société de Géographie. Tome V. 8vo.—*From the Society.*

Annales de l'Agriculture et de l'Industrie de Lyon. Tome III. 8vo.—*From the Society.*

Annales de l'Observatoire Physique Central de Russie. 1851. 2 Tomes, 4to.—*From the Observatory.*

Journal of the Horticultural Society of London. Vol. VIII., Part 4. 8vo.—*From the Society.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1854–5. No. 45.

SEVENTY-SECOND SESSION.

Monday, 4th December 1854.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read :—

1. Farther Experiments and Remarks on the Measurement of Heights by the Boiling Point of Water. By Professor J. D. Forbes.

This paper is in continuation of one printed in vol. xv. of the Royal Society's Transactions. The object of it is to test the correctness of the method of observation, and of calculating the results, there proposed; and to compare both with those of more recent authors, particularly of M. Regnault of Paris, and of Dr Joseph Hooker.

The author finds the results of his subsequent observations in 1846 in the Alps, up to heights considerably above 10,000 feet, to agree well with those previously published, made in 1842. They combine in showing a sensibly uniform fall of the boiling point at the rate of 1° for 543 feet of ascent,* which differs only 6 feet (in defect) from his previous determination. The average deviation of the in-

* In a standard atmosphere at 32° of temperature.

dividual results from the formula is only $\frac{1}{12}$th of a degree (without regard to sign).

Barometer.	Boiling Point.	Difference from my formula.	Difference from Regnault's Formula.
Inches.	Fahr.		
20·77	194°·28	+0°·22	+0°·32
20·79	194·33	−0·08	+0·01
22·40	197·94	−0·04	+0·12
22·67	198·51	−0·08	+0·06
23·15	199·52	−0·07	+0·06
23·35	199·94	+0·01	+0·15
23·89	201·04	−0·11	+0·03
23·99	201·24	−0·09	+0·08
24·02	201·31	+0·04	−0·20
24·105	201·47	−0·17	+0·03
25·14	203·51	+0·04	+0·19
28·49	209·54	−0·07	−0·06

The agreement with M. Regnault's table is also extremely close; and considering the ordinary limits of error of such observations, the writer considers it nearly indifferent for elevations under 13,000 feet which method of calculation be used.

The consistency of the results shows that the method of observation (which differs in some respects from that commonly used) and the graduation of the thermometers were satisfactory.

On carefully examining Dr Joseph Hooker's detailed results (obligingly communicated by him), which that naturalist considered to be incompatible with Professor Forbes's formula, it is shown that the inconsistencies of observation are so considerable, that it is difficult to give a decided preference to one formula rather than another, for the purpose of representing them; but that up to heights of at least 13,000 feet, a *linear* formula, or one which assumes the lowering of the boiling point to be exactly proportional to the height, seems to express the observations as well as any other; and the rate of diminution is almost the same as that deduced from Professor Forbes's observation, or a lowering of 1° for 538 feet of ascent.

The author has little doubt that M. Regnault's table (which was not published when he last wrote) does really represent the law according to which water boils more accurately than the simpler linear formula, though the difference is in most cases insensible. For all ordinary heights (or up to 12,000 feet) Regnault's table may be more accurately represented by the formula

$$h = 535\ \mathrm{T}.$$

Where h is the height in English feet, T the lowering of the boiling point in Fahrenheit's degrees, reckoning from 212°. But he

finds that Regnault's table may be represented in every case which can occur in practice, and with almost perfect accuracy, by the following formula, which it is nearly as easy to use:—

$$h = 517\ T + T^2.$$

2. On the Chemical Equivalents of Certain Bodies, and the Relations between Oxygen and Azote. By Professor Low.

The following Gentleman was duly elected an Ordinary Fellow:—

JAMES COXE, M.D.

The following Donations to the Library were announced:—

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XVI., Part 1. 8vo.

A Descriptive Catalogue of the Historical Manuscripts in the Arabic and Persian Languages, preserved in the Library of the Royal Asiatic Society of Great Britain and Ireland. By William H. Morley, M.R.A.S. 8vo.

Essay on the Architecture of the Hindús. By Rám Ráz. Published for the Royal Asiatic Society of Great Britain and Ireland. 4to.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1853. IV. Jahrgang. N^{ro} 4. October, November, December. 8vo.—*From the Institute.*

Mémoires de l'Académie Impériale des Sciences, Belles Lettres et Arts de Lyon. Classe des Lettres. Tome II. 8vo.

Mémoires de l'Académie Impériale des Sciences, Belles Lettres et Arts de Lyon. Classe des Sciences. Tome II. 8vo.—*From the Society.*

Annales des Sciences Physiques et Naturelles d'Agriculture et d'Industrie publiées par la Société Impériale d'Agriculture, &c. de Lyon. 2^{me} Série. Tome IV. 1852. 8vo.—*From the Society.*

Mémoires présentés par divers savants à l'Académie des Sciences de l'Institut Impérial de France, et imprimés par son ordre. Sciences Mathématiques et Physiques. Tome XII. 4to.—*From the Institute.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Tweede Verzameling. 4e, 9de, 10de, & 11de Deel, 1ste Stuk. 4to.—*From the Society.*

Philosophical Transactions of the Royal Society of London. 1852, Parts 1 and 2; 1853, Parts 1, 2, 3; 1854, Part 1. 4to. —*From the Society.*

Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam. 1ste Deel. 4to.—*From the Academy.*

Det Kongelike Danske Videnskabernes Selskabs Skrifter. Femfte Reeke. Naturvidenskabelig og Mathematisk Afdeling. Bd 3. 4to.—*From the Society.*

Abhandlungen, herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. 1e Bd 1e Lieferung. 4to.—*From the Society.*

Astronomical and Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1852. 4to. —*From the Royal Society.*

Natural History of New York. Palæontology of New York. By James Hall. Vols. I. and II. 4to.

——— Agriculture of New York. By Ebenezer Emmons, M.D. Vols. I. II. and III. 4to.—*From the State of New York.*

Magnetical and Meteorological Observations made at the Honourable East India Company's Observatory, Bombay, in the year 1850. 4to.—*From the Hon. East India Company.*

Astronomical Observations made at the Observatory of Cambridge. Vol. XVII., for 1846, 1847, and 1848.—*From the Observatory.*

Mémoires Couronnés et Mémoires des Savants étrangers publiées par l'Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Tome XXV. 1851–53. 4to.—*From the Academy.*

Annales de l'Observatoire Royal de Bruxelles. Tome X. 4to.—*From the Observatory.*

Compte rendu des Travaux du Congrès Général de Statistique, réuni à Bruxelles, les 19, 20, 21 et 22 Septembre 1853. Par A. Quételet. 4to.—*From the Author.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome XIII., 2me Partie. 4to.—*From the Society.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. B[d]. 7. 4to.—*From the Academy.*

Tables du Soleil exécutées d'après les ordres de la Société Royale des Sciences de Copenhague, par MM. P. A. Hansen et C. F. R. Olufsen. 4to.—*From the Society.*

Rendiconto della Societa Reale Borbonica. Accademia delle Scienze. N.S. N[ros] 4 & 5. 4to.—*From the Society.*

Atti della Reale Accademia delle Scienze, sezione della Societa Reale Borbonica. Vol. VI. 4to.—*From the Society.*

Transactions of the American Philosophical Society, held at Philadelphia. (N.S.) Vol. X., Part 3. 4to.

Proceedings of the American Philosophical Society. Vol. V., No. 50. 8vo.—*From the Society.*

Researches upon Newerteans and Planarians. By Charles Girard. 1. Embryonic development of Planocera elliptica. 4to.—*From the Author.*

Smithsonian Contributions to Knowledge. Vol. VI. 4to.

Notes on new species and localities of Microscopical Organisms. By J. W. Bailey, M.D. 4to.

Catalogue of the described Coleoptera of the United States. By Frederick Ernest Melsheimer, M.D. 8vo. 2 copies.

Seventh Annual Report of the Board of Regents of the Smithsonian Institution. 1853. 8vo.

The Annular Eclipse of May 26, 1854. Published under the authority of Hon. James C. Dobbin, Secretary of the Navy, by the Smithsonian Institution and Nautical Almanac. 8vo.—*From the Institution.*

Astronomical Observations made during the year 1847 at the National Observatory, Washington. Vol. III. 4to.—*From the Observatory.*

Patent Office Reports, published by the State of Washington. 1851–3. 3 vols. 8vo.—*From the Government of Washington.*

Transactions of the Wisconsin State Agricultural Society. 1851 and 1852. 8vo.—*From the Society.*

Medico-Chirurgical Transactions. Published by the Royal Medica and Chirurgical Society of London. Vol. XXXVII. 8vo.—*From the Society.*

The Philosophy of Physics, or Process of Creative Development. By Andrew Brown. 8vo.—*From the Author.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1852, Nros 2, 3, & 4; 1853, Nros 1 & 2. 8vo.—*From the Society.*

Novorum Actorum Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vol. XXIV. Pars 1. 4to.—*From the Academy.*

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. 1853. 4to.

Monatsbericht der Königl. Preuss. Akademie der Wissenschaften zu Berlin. August 1853—Juli 1854. 8vo.—*From the Academy.*

Nachrichten von der Georg-Augusts-Universität und der Konigl. Gesellschaft der Wissenschaften zu Göttingen. 1853. 12mo. —*From the Society.*

Studien des Göttingischen Vereins Bergmannischer Freunde. In namen desselben herausgegeben von J. F. L. Hausmann. Bd 1, heft 3. 8vo.—*From the Editor.*

Siluria. The History of the oldest known Rocks containing Organic Remains, with a brief sketch of the distribution of Gold over the Earth. By Sir R. I. Murchison. 8vo.—*From the Author.*

Museum of Practical Geology and Geological Survey. Records of the School of Mines and of Science applied to the Arts. Vol. I., Part 4. 8vo.—*From the Museum.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. (N.S.) Nos. 45 and 46. 8vo.—*From the Society.*

Proceedings of the Architectural Institute of Scotland. Session 1853–54. 8vo.—*From the Institute.*

Twenty-first Annual Report of the Royal Cornwall Polytechnic Society. 1853. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVII., Part 2. 8vo.—*From the Society.*

The Assurance Magazine, and Journal of the Institute of Actuaries. Vol. V., Part 4, and Vol. V., Part 1. 8vo.

List of Members of the Institute of Actuaries of Great Britain and Ireland. 1854–5. 8vo.—*From the Institute.*

Athenæum. Rules and Regulations, Lists of Members, and Donations to the Library, 1852, with Supplement for 1853. 12mo. —*From the Athenæum.*

Monday, 18th December 1854.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read:—

1. Some Observations on the Salmonidæ. By John Davy, M.D., F.R.S., Lond. and Edin., Inspector-General of Army Hospitals.

These observations are given in seven sections:—

In the 1st, the author treats of the air-bladder of these fish, and the contained air, which he found, in every instance that he examined it, to be chiefly azote.

In the 2d, he points out a mistake he had fallen into in the instance of the female fish, as regards its abdominal aperture, which, in a former paper he had described as open only for the passage of the ova; on further examination made on the larger species, he has ascertained, that though virtually closed, except during the spawning time, it is not absolutely, either by a membrane or adhesion.

In the 3d, on the breeding localities of the Salmonidæ, he states his opinion, that running water is not essential to the hatching of the ova, and he adduces instances in proof and illustration.

In the 4th, which is on the variable time of the hatching of the ova, he describes examples of difference as to time of the production of the young fish under circumstances apparently identical, or circumstances only very slightly different, tending to show the influence of a *vis insita* in the several ova.

In the 5th, on circumstances and agencies likely to take effect on the young fish, he notices two trials,—one on keeping the young fish in darkness after quitting the egg, which had no marked influence; the other, on keeping them in the smallest portion of water capable of covering them, in relation to the position of young fish during a time of drought; in one experiment life was protracted 52 hours, in another 74.

In the 6th, on the food of the young fish, he endeavours to prove that the food most suitable for them, and for which they are best

fitted, is the infusoria. Young charr, under his observation, attained their perfect form and became fit to be set at large, to which no food had been given, and were, it is presumed, after the absorption of the yolk, fed and nourished by these microscopic animalcules.

In the last section, he submits some remarks on the vexed question of the Parr, viewed as a species, and comes to the conclusion that till a parr is found propagating its kind, proof must be held to be wanting of the existence of such a fish, a true species distinct from the salmon or sea-trout fry.

2. On the Structural Character of Rocks. Part III., embracing Remarks on the Stratified Traps of the neighbourhood of Edinburgh. By Dr Fleming.

The author referred, in the first instance, to the character of stratification, illustrating the subject by specimens displaying the intermittent character of the carrying agent and of the supply of material, pointing out the Hailes Quarry as furnishing the best example in the neighbourhood of the repetitions of strata. He then stated the views of Townson, Whitehurst, and Jameson, as to the relation of the trap rocks to the sandstones with which they are interstratified. He then took notice of a statement in vol. xiii. of the Transactions of the Society, recorded by Lord Greenock, that Edinburgh may be considered as a *valley of elevation*, the trap rocks in the neighbourhood dipping outwards as from a common centre. This opinion, he stated, was true in reference to the rocks on the east and west sides of the city, but not true as to those on the south and north, or at Blackford and Burntisland.

Dr Fleming then stated that there were nine masses of trap in the neighbourhood, included in the sandstones, all of them having some peculiar structural characters—viz. Calton Hall, Salisbury Crags, Arthur's Seat, Lochend, Hawkhill, Blackford, Craiglockhart, Corstorphin, and Granton. At this part of the paper he made some remarks on the so-called "outburst of trap" of Inchkeith, stating that the island consisted of at least a dozen of beds of trap alternating *regularly* with acknowledged sedimentary beds of sandstone, shale, and limestone, containing organic remains.

The author then commenced his survey of the stratified traps of

the neighbourhood, by considering particularly the structural character of the Calton, or, as it was termed at an earlier period, the Caldton. This trappean mass he regarded as extending from Greenside to Samson's Ribs, including Heriot Mount, St Leonard's, and the Echoing Rock. The Calton-hill had been described by Townson, Faunas St Fond, Jameson, Webster, Boué, Saussure, Cunningham, Milne, and Maclaren.

Dr Fleming then illustrated his views of the sedimentary character of the whole hill, by tracing on the Ordinance map the coloured spaces occupied by the twelve beds of which the hill consists, assisted by a coloured section. The peculiarities of each bed in regard to its structure and mineral contents were pointed out; and he concluding by noticing the four concretionary masses of *columnar basalt* distributed in the deposit, and the more interesting of the simple minerals of the hill, especially the Sarcite of Townson, first characterized from Calton specimens and afterwards known as Cubizite and Analcime, exhibiting a specimen which he had procured from the hill when a student at the University.

The following Gentleman was duly elected an Ordinary Fellow:—

ERNEST BONAR, Esq., Castle Dobel, Styria.

The following Donations to the Library were announced:—

Archæologia; or, Miscellaneous Tracts relating to Antiquity, published by the Society of Antiquaries of London. Vols. XXXII., XXXIII., XXXIV., XXXV. 4to.

Proceedings of the Society of Antiquaries of London. Vols. I., II.; Vol. III., Nos. 37–40. 8vo.

Catalogue of Roman Coins collected by the late Rev. Thomas Kerrich, M.A., F.S.A., Prebendary of Wells and Lincoln; and presented by his Son, the Rev. Richard Edward Kerrich, M.A., F.S.A., to the Society of Antiquaries of London. 8vo.

List of the Society of Antiquaries of London, on 23d April 1854. 8vo.—*From the Society.*

Memorie della Academia delle Scienze dell' Istituto di Bologna. Tomo IV. 4to.—*From the Academy.*

Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Band XIII. 4to.

Actes de la Société Helvétique des Sciences Naturelles. Réunie à Sion, les 17, 18, et 19 Août 1852. 8vo.

Actes de la Société Helvétique des Sciences Naturelles. Réunie à Porrentray, les 2, 3, et 4 Août 1853. 8vo.

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nros 258-313. 8vo.

Ueber die Symmetrische Verzweigungsweise dichotomer Inflorescenzen. Von H. Wydler. 8vo.—*From the Society.*

Abhandlungen der Historischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. Bde 7. 1ste Abtheil. 4to.

Gelehrte Anzeigen herausgegeben von Mitgliedern der K. Bayerischen Akademie der Wissenschaften. Bd 36, 37. 4to. —*From the Academy.*

Bulletin de la Société de Géographie. 4me Serie. Tome VII., 8vo. —*From the Society.*

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tome XX. 3e Partie. Tome XXI. 1re Partie. Annexe aux Bulletins, 1853–4. 8vo.—*From the Academy.*

Transactions of the Pathological Society of London. Vol. V. 8vo. —*From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool, during the 43d Session, 1853–54. No. 8. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. XVIII. Nos. 52, 53, 54. 8vo.—*From the Editors.*

The Quarterly Journal of the Geological Society. Vol. IX., Part 1. Vol. X., Parts 2 and 3. 8vo.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1854. No. 1, Jan. Feb. Marz. (2 copies.) 8vo.—*From the Institute.*

Rendiconto della Societa Reale Borbonica. Accademia delle Scienze. N.S. (Jan.–June, 1853.) 4to.—*From the Society.*

Repertorio Italiano per la Storia Naturale. Repertorium Italicum complectens Zoologiam, Mineralogiam, Geologiam, et Palaeontologiam. Cura J. Josephi Bianconi. Vol. I. 8vo.—*From the Author.*

Jahresbericht über die Fortschritte der reinen, Pharmaceutischen und Technischen Chemie, Physik, Mineralogie und Geologie, herausgegeben von Justus Liebig & Hermann Kopp. 1853. 8vo.—*From the Editors.*

Universalità dei mezzi di previdenzi, difesa, e salvezza per le calamita degl' incendi opera premiata in concorso dalla Accademia delle Scienze dell' Istituto di Bologna. Scritta da Francisco del Guidice. 8vo.—*From the Author.*

Bulletins de la Société Vaudoise des Sciences Naturelles. Tome III. Nos. 25–28, 30, 31, 32. 8vo.—*From the Society.*

Proceedings of the Academy of Natural Science of Philadelphia. Vol. III. Nos. 3–6. 8vo.—*From the Society.*

Notices of the Meetings of the Members of the Royal Institution of Great Britain. Part 4. Nov. 1853–July 1854. 8vo.—*From the Society.*

Report of the Commissioner of Patents for the year 1853. Part I. Manufactures.—*From the Government of Washington, U. S.*

The Annular Eclipse of May 26, 1854. Published under the authority of Hon. James C. Dobbin, by the Smithsonian Institution and Nautical Almanac. 8vo.

Seventh Annual Report of the Board of Regents of the Smithsonian Institution for the year 1852. 8vo.—*From the Institution.*

Exploration of the Valley of the Amazon, made under the direction of the Navy Department. By William Lewis Herndon and Lardner Gibbon. Part 1. By Lieut. Herndon.—*From the Author.*

Transactions of the Cambridge Philosophical Society. Vol. I. Part 3. 4to.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVI. Part 3. 8vo.

General Index to the first fifteen volumes of the Journal of the Statistical Society of London. 8vo.

List of Fellows of the Statistical Society of London. Session 1854-1855. 8vo.—*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. XXII. 4to.—*From the Society.*

Journal of the Horticultural Society of London. Vol. IX. Parts 2 and 3. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Edited by the Secretaries. Nos. 237–242. 8vo.—*From the Society.*

Mémoires de la Société Impériale des Sciences de l'Agriculture et des Arts de Lille. 1853. 8vo.—*From the Society.*

Die Fortschritte der Physik in den Jahren 1850 und 1851. Dargestellt von den Physikalischen Gesellschaft zu Berlin. 6 & 7 Jahrgang. 1te Abtheil. 8vo.—*From the Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bde. XI. & XII. 8vo.—*From the Society.*

Address to the Boston Society of Natural History. By John C. Warren, M.D. 8vo.—*From the Author.*

Monthly Notices of the Royal Astronomical Society. Vol. XIII., 1852–3. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. XVII., No. 51. 8vo. —*From the Editors.*

Tuesday, 2d January 1855.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read :—

1. Notes on some of the Buddhist Opinions and Monuments of Asia, compared with the Symbols on the Ancient Sculptured "Standing Stones" of Scotland. By Thomas A. Wise, M.D.

The general identity, in idea and design, of the ancient monuments of southern and western Europe with those of Hindostan, was shown and illustrated by drawings of cairns, barrows, kist-vaens, cromlechs, circles of stones, and obelisks, or, as they are frequently called, standing stones, as found in both regions. The connection between the inhabitants of these regions was further shown by the physical conformation of the races, by the similarity of many of their manners, customs, and observances, and by the decided and extensive affinity of the Celtic, and other languages of western Europe, with the Sanscrit. The early connection which thus appears to have existed

was shown to indicate a line of inquiry, by following which much of the obscurity, resting over the earliest monuments and history of western Europe, may be cleared away. In particular, reasons were adduced for believing that the widely different doctrines of Buddhism, originating in Asia, at a period when some intercourse was still maintained between the cognate but widely separated races, were carried westward by missionaries, who, finding the people unprovided with a written language, had recourse to symbols, already used in the East, to express their fundamental doctrines. The deity or spirit (Buddha) was designated, as in India, by a wheel or circle; inorganic matter (Dharma) by another circle, or by a monogram, formed of the initial letters of the elements; and organic matter (Sangha) by some embryotic form of animal or vegetable life, or by a circle, or an imperfect crescent. The symbol of three single circles is found in both regions: This triad is found in India in the temple of Ellora, and other Buddhist temples, and in Scotland on the Kineller stone. In the progress of advancement of the arts these simple forms of symbols were changed for temples, and idols were added by the rich and powerful Buddhists of Asia.

Among the ruder and more ignorant inhabitants of Scotland, the arrangement of the symbols required to be altered, to suit the people for whom they were intended: Spirit and Matter continued to be represented by two circles, but connected by a belt, and crossed by a bar uniting the extremities of two sceptres, to indicate the supreme power of these (according to the Buddhist creed) co-ordinate and all-originating principles; while organised matter was represented by a crescent, flower, a dog-like embryo, or some other rude representation of life.

The modifications of the serpent figure, and the Buddhist cross or sacred labyrinth, as symbols of the spiritual deity; and the occurrence of lions, camels, centaurs, with the honour paid to trees, &c., on the ancient sculptured obelisks of Scotland, were also adduced as proofs of an oriental origin, or connection.

Reasons were given for the number of these stones in that part of Scotland forming the ancient Pictish kingdom; of which the inhabitants, after a temporary profession of Christianity, seemed to have declined from the faith.

2. Note on the extent of our knowledge respecting the Moon's Surface. By Professor C. Piazzi Smyth.

Taking advantage of the special attention paid at present to certain astronomical disquisitions, the author called attention to a particular point connected with the moon, which was first stated by the author of "The Plurality of Worlds," and then made by him to prove that the moon must be uninhabited, and thence to lead to the conclusion that all the other planets were uninhabited also. This point was, that "observations having been made on the moon abundantly sufficient to detect the change caused by the growth of such cities as Manchester and Birmingham, no such changes having been perceived, the theory of non-habitation may be indulged in."

But after having indicated the sort of appearance that those collections of human habitations would make when transferred to the moon, Professor Smyth proceeded to show that the registered and published observations of the moon are by no means sufficiently accurate to be used to test this question: and that they do show changes, and often to a far greater amount than the mere building of a lunar Manchester would occasion: but such changes bear the impress of error of observation. More powerfully still was this brought out, on comparing even the best of the published documents with some manuscript drawings of the Mare Crisium in the moon, recently made at the Edinburgh Observatory; and the author hoped that this statement of the imperfection of existing maps would lead to observers generally applying themselves to improve this important and interesting field of astronomy.

3. On the Interest strictly Chargeable for Short Periods of Time. By the Rev. Professor Kelland.

Considerable attention has of late been bestowed on the equitable mode of computing the interest which ought to be charged for fractional portions of a year. Various opinions have been offered relative to the solution of the problem. The basis on which they mutually rest, and on which it appears to me that every solution of the problem must rest, is this—"That the interest chargeable for any fractional part of a year shall at the end of the year amount to a

sum which bears the same proportion to the whole annual interest that the period bears to the whole year." But there are considerations affecting, not the interest, but the principal, which enter largely into the solution of the problem. The date at which both interest and principal are due is the end of the year; it is evident, therefore, that not only ought a less half-year's interest to be paid at the end of the first six months than at the end of the second, but also that the principal itself, if repaid at the end of the first six months, is less valuable for the next period than it would have been if suffered to complete its year. The solution of the problem has accordingly been made to depend on the following assumption—"That both principal and interest recommence a new year at the date of the payment of the latter." I believe I am correct in saying that this is the form in which the problem is usually solved, and I have no objections to make to it; but I can conceive circumstances, in connection with life assurance payments, to which it is not strictly applicable; and I have thought that it would not be unacceptable to those who take an interest in the subject, if I presented the solution of the problem in a new form, obtained by viewing it in another light. With the practical bearing of any solution, I have no concern; it is the province of the actuary to ascertain, in any case presented to him, whether the one or the other hypothesis is applicable. But I do not think it would be difficult to point out examples of the operations of banks and life assurance companies where the interest must be regarded as simply the payment of a sum before it has become due, the capital out of which that sum has accrued being continued in its steady progress to the end of the year. However this may be, whether the problem have a practical bearing or not, it is easy to see the propriety of the following hypothesis as the basis of a theoretical solution of the question—"That the interest chargeable for short periods of time may be deduced from considerations which affect the interest alone." This hypothesis obviously presents us with the following problem, which we have solved:—

Problem.—To find the interest which must be paid at the end of a fractional portion of a year, so that, being presumed to accumulate at the same rate and in the same way in which it has itself been produced, it shall, at the end of the year, amount to the exact portion of the whole annual interest which would then have been payable. For example, to find the interest of L.100 for a quarter

of a year at 4 per cent., so that, at the end of the year, it shall, by accumulating in the same way, amount to L.1.

Let the interest of L.1 for a year, payable at the end of the year, be i; and let the interest for the first xth portion of a year, payable at the end of the period, be I_x, then, we ought to have—

$$I_x (1 + I_{1-x}) = x\,i$$

$$\text{or,} \qquad I_x + I_x\, I_{1-x} = x\,i \qquad . \quad . \quad . \quad (1.)$$

To solve this equation, substitute $1-x$ for x, and there results

$$I_{1-x} + I_x\, I_{1-x} = (1-x)\,i$$

whence, by subtraction,

$$x\,i - I_x = (1-x)\,i - I_{1-x} \qquad . \quad . \quad . \quad (2.)$$

This equation shows that the excess of the proportional part of the year's interest above the sum payable is the same for complementary portions of a year.

Substituting the value of I_{1-x} from equation (2), we get

$$I_x^2 + I_x \left\{ 1 + (1-x)\,i - x\,i \right\} = x\,i$$

$$I_x = \tfrac{1}{2} \left\{ 2\,x\,i - (1+i) \right\} + \tfrac{1}{2}\sqrt{(1+i)^2 - 4\,x\,i\,(1-x)\,i}$$

$$= x\,i - \frac{1+i}{2} \left\{ 1 - \sqrt{1 - \frac{4\,i^2}{1+i^2}\,x\,(1-x)} \right\}$$

The following Gentleman was duly elected an Ordinary Fellow :—

James B. Fraser, Esq., Glasgow.

The following Donations to the Library were announced :

Flora Batava. 176 Aflevering, 4to.—*From the King of Holland.*

Transactions of the Architectural Institute of Scotland. Vol. III., Part 1. 8vo.—*From the Institute.*

Magnetische Ortsbestimmungen ausgeführt an verschiedenen Puncten des Konigreichs Bayern und an einigen auswartigen Stationen. Von Dr J. Lamont. 1 Theil. 8vo.

Annalen der Königlichen Sternwarte bei München. VI. Band. 8vo.—*From the Observatory.*

A Monograph of the British Nudibranchiate Mollusca; with figures of all the species. By Joshua Alder and Albany Hancock. Part 6. 4to.—*From the Ray Society.*

Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. N. S., No. XLVII. 8vo. *From the Society.*

Almanaque Nautico para el año 1855. (San Fernando.) 8vo.—*From the Marine Observatory of San Fernando.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt 1853. No. 3. (Juli, August, September.) 8vo.—*From the Institute.*

Transactions of the Royal Scottish Society of Arts. Vol. IV., Part 2. 8vo.—*From the Society.*

Proceedings of the Royal Society. Vol. VI., Nos. 91–101. 8vo.—*From the Society.*

Boston Journal of Natural History, containing Papers and Communications read before the Boston Society of Natural History, and published by their direction. Vol. VI., No. 3. 8vo.

Proceedings of the Boston Society of Natural History. Jan. 1, 1851—Nov. 16, 1853. 8vo.—*From the Society.*

Proceedings of the American Academy of Arts and Sciences. Vol. III., pp. 1–104. 8vo.—*From the Academy.*

Monday, 15th January 1855.

Dr TRAILL, Curator of the Library, in the Chair.

The following Communications were read:—

1. Some additional Experiments on the Ethers and Amides of Meconic and Comenic Acids. By Henry How, Esq. Communicated by Dr Anderson.

The author commenced by alluding to his analysis of amidomeconic acid in a previous paper, and to the objections urged against the formula he had assigned to it.

By referring to his former analyses, and to a later one, he showed that the empirical formula of the acid could not be that suggested by Messrs Wurtz and Gerhardt, but that his results could only lead to that which he had formerly given, namely—

$$C_{84}\,H_{39}\,O_{78}\,N_7.$$

The discovery of a new ammonia salt of this acid, differing from the yellow one formerly described, has led him to modify the rational formula of the acid; and he now gives for the acid and its two ammonia salts the formulæ,

Meconamidic acid, $6\,HOC_{84}\,H_{24}\,N_7\,O_{63} + 9\,HO$.
Yellow ammonia salt, $6\,NH_4\,OC_{84}\,H_{24}\,N_7\,O_{63} + 3\,NH_3 + 6\,HO$.
White do. do., $6\,NH_4O,\ C_{84}\,H_{24}\,N_7\,O_{63}$.

He added, however, that these formulæ deviated much from what analogy would lead us to expect; and that this want of analogy with other compounds could only be cleared up by farther investigation.

He then described an amide, biamidomeconic acid, obtained by the action of ammonia on biethylated meconic acid. Its formula is—

$$HOC_{14}\,H_5\,N_2\,O_9 + Aq.$$

He mentioned also the formation of a black oily substance, possibly the triethylated meconic acid.

The next section of the paper treated of the action of iodide of ethyle in comenic acid, which yields the substance formerly described as comenamic or ethylocomenic acid,—

$$HOC_4\,H_5\,OC_{12}\,H_2\,O_8.$$

This the author considers to be the true comenic ether. On trying to obtain an analogous amyle compound, he obtained what seemed to be the same ethyle compound.

He next stated that comenic acid, heated to 300° F. with water for some days, undergoes entire decomposition, the products being carbonic acid, and a shining black solid, not yet examined.

He then described the action of hydrochloric acid on comenic acid and alcohol, which yield a curious compound, which crystallizes in long silky needles, and the formula of which is—

$$C_4\,H_5\,OC_{12}\,H_4\,NO_7,\ 2\,HO + HCl.$$

It is readily decomposed, yielding comenamic ether. It is therefore a compound of that ether with hydrochloric acid.

Comenamic ether is readily obtained from it by the action of ammonia on its hot aqueous solution. The ether forms colourless prisms, the formula of which is—

$$C_4\,H_5\,OC_{12}\,H_4\,NO_7.$$

By nitric acid it is converted into binoxalate of ammonia. When heated, it melts at above 400° F., and on cooling, concretes to a crystalline mass, or sometimes takes the form of a pillared solid mass.

The paper concludes with a tabular list of the compounds described in it, with their formulæ.

2. On a Revision of the Catalogue of Stars of the British Association. By Captain W. S. Jacob, H.E.I.C., Astronomer at Madras. Communicated by Professor C. Piazzi Smyth.

After a brief allusion to the importance of catalogues of stars in general, as the foundation of exact astronomy, the circumstances connected with the publication of the important Catalogue of Stars by the British Association were mentioned.

Many of the materials were well known to be imperfect at the time of printing, but that step, it was thought, would strongly induce all astronomers to improve the defective portions.

This has since been found to be the case extensively, and the present paper is an important contribution to that end.

After mentioning his practical methods of ensuring the greatest possible accuracy, Captain Jacob describes the result of an examination of 1503 out of the 8377 stars of which the Catalogue of the Association consists, and states that the large number 55 are altogether missing in the sky, that 71 differ from their computed places by more than 2 sec. of time, or 10″ of N.P.D.; but that the rest are all very exact, seldom differing by more than 0·2 of a second of time.

Some of the above cases of large difference, he thinks caused by proper motion, and recommends further observations at a future period, to settle the question.

3. Notice of Ancient Moraines in the Parishes of Strachur and Kilmun, Argyleshire. By Charles Maclaren, F.R.S.E.

The first of the moraines referred to is in Glensluan, a valley near Strachur, about two miles and a half in length, and two-thirds of a mile in breadth. It is bounded on the east, west, and south

sides by mountains from 800 to 2000 feet in height. At the north or lower end, where it opens into Glen Eck, there is a series of mounds of clay and gravel, crossing the valley like embankments, and spread over a space of about 1800 feet in length, and from 350 to 600 in breadth. They are from 20 to 100 feet in depth. These mounds have turned the river Sluan from its direct course down the middle of the valley, and forced it to cut a passage towards the east side. They consist of piles of incoherent clay and gravel, mixed with blocks, all derived from the rock (mica slate) which bounds the valley. In form, materials, and position, they exactly resemble the terminal moraines found at the foot of valleys occupied by glaciers; and if found in a similar situation in the Alps, would be at once recognised as terminal moraines.

The other moraines are in Glenmessan, about 10 miles southward from Glensluan. They consist, first, of two mounds of clay and gravel, mingled with blocks, stretching across the foot of Glenmessan like embankments, and of the height of 40 and 77 feet respectively; secondly, of four other detached mounds, from 25 to 30 feet in height, scattered over a small plain or meadow, half a mile farther south. In the valley of Glenmessan, grooved rocks, and other marks of glacial action, are also found, and strengthen the conclusion, that a glacier once occupied the valley, and produced the mounds of clay and gravel.

Monday, 5th February 1855.

The Right Rev. Bishop TERROT in the Chair.

The following communications were read:—

1. On the Properties of the Ordeal Bean of Old Calabar, Western Africa. By Dr Christison.

In various parts of Western Africa it appears to be the practice to subject to the ordeal by poison persons who come under suspicion of having committed heinous crimes. On the banks of the Gambia river the poison used for the purpose is the bark of a leguminous tree, the ***Fillæa suaveolens*** of MM. Guillemin and Perottet. In the neighbourhood of Sierra Leone it is the bark of ***Erythrophleum guinëense***,

which some botanists have considered identical with the former species. On the Congo river, Captain Tuckey found that either this species, or an allied species of the same genus, was in constant use for the same purpose. These barks, when their active constituents are swallowed in the form of infusion, sometimes cause vomiting; and then the accused recovers, and in that case is pronounced innocent. More generally the poison is retained; and then the evidence of guilt is at the same time condemnation and punishment; for death speedily ensues.

In the district of Old Calabar, the poison used for the trial by ordeal is a bean, called Eséré, which seems to possess extraordinary energy and very peculiar properties. It has been lately made known to the missionaries sent by the United Presbyterian Church in Scotland to the native tribes of Calabar; and to the Rev. Mr Waddell, one of these gentlemen, the author was chiefly indebted for the materials for his experiments, as well as for information as to its effects on man. According to what the missionaries often saw, this poison is one of great energy, as it sometimes proves fatal in half an hour, and a single bean has proved sufficient to occasion death. None recover who do not vomit it. The greater number perish. On one occasion forty individuals were subjected to trial, when a chief died in suspicious circumstances, and only two recovered.

The author found the bean to present generally the characters of a *Dolichos*. It has been grown at his request both by Professor Syme and at the Botanic Gardens by Mr M'Nab; and it proves to be a perennial leguminous creeper, resembling a dolichos, but it has not yet flowered. The seed weighs about forty or fifty grains. It is neither bitter, nor aromatic, nor hot, and differs little in taste from a haricot bean. Alcohol removes its active constituent, in the former of an extractiform matter, amounting to 2·7 per cent. of the seed. The author could not obtain an alkaloid from it by any of the simpler processes for detaching vegetable alkaloids.

By experiment on animals, and from observation of its effects on himself, the ordeal bean has a double action on the animal body: it paralyses the heart's action, and it suspends the power of the will over the muscles, causing paralysis. It is a potent poison, for twelve grains caused severe symptoms in his own person, although the poison was promptly evacuated by vomiting, excited by hot

water. The alcoholic extract has the same effect and action with the seed itself.

2. Experiments on the Blood, showing the effect of a few Therapeutic Agents on that Fluid in a state of Health and of Disease. By James Stark, M.D., F.R.C.P.

The author stated that when he commenced these experiments, in 1832, his object was to ascertain, *first*, what effect different diseases had on the constitution of the blood; and, *secondly*, what effect various therapeutic agents had on that fluid in a state of health and of disease. As the experiments of Andral and others, published since these experiments were commenced, had done much to elucidate many points of the first subject of inquiry, the author limited this communication to a small portion of the latter inquiry.

The effect of bloodletting on the constitution of the blood in pneumonia was first described. It was shown that each successive bloodletting increased the proportion of fibrin in the blood, which fibrin was already in excess in consequence of the existence of the inflammatory disease. Finding that bloodletting had always this effect in inflammation, the author made experiments on the healthy subject, to ascertain whether bloodletting had any effect on the constitution of the blood, and found that it produced an increase in the proportion of fibrin as compared with the other solids of the blood. On bleeding sheep rapidly to death, the suddenness of the death prevented the increase being very marked; but when the same animals were bled slowly to death, the fibrin in the last drawn blood was found to be nearly a third greater relatively to the other solids of the blood than in the first drawn blood.

To illustrate this part of the subject, the author pointed out the bearing of these experiments in the treatment of a few diseases, as inflammations, apoplexy, hæmoptysis, purpura, and hæmorrhage from a divided blood-vessel; and also their bearing on the phenomena of inflammation.

The effects of alkalies and alkaline carbonates on the blood, and in the treatment of inflammatory affections, was next noticed; after which the author passed to the consideration of another important therapeutic agent—mercury.

He showed that when mercury was administered internally, it

caused a reduction in the proportion of the fibrin of the blood; produced a state exactly the opposite of that caused by inflammation—in fact, caused a state of the blood exactly analagous to that existing in scurvy. He therefore inferred that mercury would prove the most valuable remedy in the treatment of inflammatory diseases; and accordingly, in trying its effects, first in pneumonia, and afterwards in other inflammatory diseases, he found, that just in proportion as the mercury was absorbed, the excess of fibrin in the blood, which had been produced by the inflammation, diminished, and with this diminution all the inflammatory symptoms subsided, and the cure went on satisfactorily. As the object in these cases was to produce a rapid absorption of the mercury, the calomel was given in such small doses as not to act on the bowels (generally the fourth or the sixth of a grain every hour), and in no case was it conjoined with opium.

The paper was concluded by pointing out that these experiments gave no countenance whatever to the doctrines of Hahneman, but confirmed the truth of the adage of Hippocrates, "that contraries are the cure of contraries."

3. Extracts from a Letter from E. Blackwell, Esq., containing Observations on the Movement of Glaciers of Chamouni in Winter. Communicated by Professor Forbes.

"The accessibility of the glaciers, even up to a considerable height, is at this season a question of mere physical force. I have made within the last few days two excursions into the region of perpetual snow. The first of these was on the 6th of January, and was to the summit of the glacier of Blaitière, several hundred feet above the point where I had noted the line of the névé in September and October; the second was on the 13th, when I succeeded in reaching the junction of the glaciers of Bossons and Tacconaz, near the Grands Mulets. This junction is exactly at the commencement of the névé, as I remarked between the months of August and October, on six different occasions, when I passed there on my way to and from Mont Blanc, the Dôme de Gouté, &c. In both these expeditions I was struck by the excessive power of the sun; the greater apparent warmth, even in the shade, as compared to the valley of Chamouni; and the sudden chill which followed sunset. There was also much less snow at

these heights than in the valley, and I have no hesitation in saying that in winter very little snow falls upon the higher summits. The snow-falls in the valley are *invariably* brought by a low creeping fog, which comes up from Sallanches. It seldom overtops the Col de Voza, and the Aiguilles appear bright and sunny in the gaps of the cloud. It is in spring and autumn that these higher peaks are powdered by every storm; *now* the dispersing clouds leave them as dark as before they gathered. I fancy this winter is unusually cold; every one is crying out, and complaining that the potatoes are frozen in deep cellars. I have seen Reaumur's thermometer at — 25° at 5½ in the afternoon, and I think it may reasonably be supposed that it may have fallen to — 30° during the night; wine has frozen on my table before a fire. In the woods the trees crack with the intense frost, and there is from 2½ to 3 feet of snow in the valley without drifts; on the glacier of Blaitière there is only from 1 to 2 feet.

" In spite of all this cold the glaciers advance steadily. The glacier de Blaitière, terminating above the line of trees, pushes its moraine in front of it, and seems to be on the increase. Now this is a very *shallow* glacier, and, as I have said, covered with but little snow. Is it possible that infiltrated water can have any action whatever under such circumstances?

" I will here state a few results of careful observation, and I hope that, even should they appear strange, you will yet consider them worthy of confidence. I have no theodolite, but I have a prismatic compass, and will take the bearings of various points from my stations should you deem it advisable.

" The torrent of Bossons has been quite dry ever since the beginning of November, and I have profited by this circumstance to endeavour to determine the motion of the ice within the vault, nearly in contact with the ground. I believe it is usually supposed that the reason why the termination of a glacier seems stationary in summer, is that there the waste predominates over the supply. It seemed to me, therefore, that in winter, when there is actually no waste—the torrent being perfectly dry, and its subglacial bed even *dusty*—the end of the glacier ought to be thrust forward into the valley by the pressure behind. I accordingly, with some little difficulty, fixed a station on the ridge or back of the glacier, near the lower extremity; the result is, that *the ice there is nearly sta-*

tionary. This is doubtless a clue to the assertions of some authors, 'that the glacier is stationary in winter;'—they only looked at *the end*. What becomes, then, of the ice continually descending from above? Does it not go to thicken the whole mass, accumulating behind the more rigid portion below, as water behind a dam? I have no space to add more at present, but will write again if I have your approval of my proceedings. Meanwhile I have fixed (yesterday) an intermediate station, for the purpose of determining *where* this comparative immobility begins. I have noted my observations, and kept a register of weather, &c. I give one observation to show the difference between the middle and lower glaciers:—

From December 28 to January 11—14 days.

Middle glacier (somewhat above where it is usually crossed).
Centre, 14 ft. 7 in. (fourteen feet, seven inches).
Side, 11 ft. 6 in. (eleven feet, six inches).

Lower glacier during the same period.
Ridge, 1 ft. 7 in. (one foot seven inches).
Interior of vault, 0 ft. 2 in. (two inches)."

Observations on Mr Blackwell's Letter by Professor Forbes.

The cold described (—25° to —30° of Reaumur—24½° to —35½° of Fahrenheit)—appears so excessive as to be unlikely; I have therefore written to enquire if the thermometer could be depended on.

It is highly satisfactory that the superficial velocity of the glacier of Bossons—about a foot in twenty-four hours—coincides closely with the measurements of my guide, Auguste Balmat, some years since, on the same glacier, at the same season.

With respect to the ice of the glacier of Blaitière, which is above the level of trees—probably at least 7000 feet above the sea—being still in motion, it merely confirms the deductions long ago made by me as to the continuity of glacier motion even in winter. And as to the apparent paradox of water remaining uncongealed in the fissures of the ice at this season, though I have nowhere affirmed the presence of liquid water to be a *sine qua non* to the plastic motion of glaciers, it would be difficult to assert positively that it is everywhere frozen in the heart of a glacier even in the depth of winter. Heat, we know, penetrates a glacier (up to 32° and no further), not only by conduction, but much more rapidly by the percolation of water; but cold penetrates *solely* by conduction, and that according to the same law as in solid earth, though it may be more

rapidly. Now, it is known that at a depth of 24 or 25 feet in the ground, the greatest summer heat has only arrived at Christmas. A similar retardation in the effects of cold must occur in glaciers. Not a particle of water detained in the capillary fissures can be solidified until its latent heat has been withdrawn.

The contrast the writer draws between the glaciers of Blaitière and Bossons, the latter of which is some thousand feet lower in point of level, is curious and instructive. The former, he says, appears the more active, and is pushing forwards its *moraine;* whilst the latter, at its lower extremity, and in contact with the ground, is scarcely moving at all.

There is nothing of which we know less than the cause of the seemingly capricious advance and retreat of the extremities of glaciers at the same time and under, seemingly, the same circumstances.

In the present case, I will only mention as a *possible* explanation, that the glacier of Blaitière probably possesses a continuous slope, from its middle and higher region down to its lower extremity. But the Bossons, after its steep descent from Mont Blanc, proceeds a long way on a comparatively level embankment, which at an early period it cast up of its own debris, and in which it has dug itself a hollow bed in which it nestles. The angular slope of the bottom in contact with the soil is very probably much less than in the case of the glacier of Blaitière. Now, when winter has dried up the percolating water, the viscosity of the mass may be insufficient to drag it over the less slope although it carries it over the greater. That the motion of the ice close to the ground should be nearly nothing, whilst the more superficial part of the glacier over-rides it by its plasticity, is as a separate fact quite in accordance both with theory and previous observation.

But as the *snout*, or lower end of the glacier of Bossons, is almost stationary, whilst the middle region is moving at the rate of a foot a day, Mr Blackwell very pertinently asks, "What becomes, then, of the ice continually descending from above? Does it not go to thicken the whole mass, accumulating behind the more rigid portion below, as water behind a dam?" I answer, undoubtedly; and he will find this explanation given ten years ago in my *Travels in the Alps* (2d edit., p. 386.) Speaking of the superficial waste of the glaciers in summer and autumn, and the manner in which it is re-

paired before the ensuing spring, I there observed, "The main cause of the restoration of the surface is the diminished fluidity of the glacier in cold weather, which retards (as we know) the motion of all its parts, but especially of those parts which move most rapidly in summer. The disproportion of velocity throughout the length and breadth of the glacier is therefore less, the ice more pressed together, and less drawn asunder; the crevasses are consolidated, while the increased friction and viscosity causes the whole to swell, and especially the inferior parts, which are the most wasted."—(See also *Seventh Letter on Glaciers*, p. 435 of Appendix to the same work.)

The following Gentleman was elected an Ordinary Fellow:—

Dr Stevenson Macadam.

Monday, 19*th February* 1855.

JAMES TOD, Esq., in the Chair.

The following Communications were read:—

1. On the Mechanical Action of Heat:—Supplement to the first Six Sections, and Section Seventh. By W. J. Macqueen Rankine, Esq., C.E., F.R.SS. Lond. and Edinb.

This paper is written in continuation of a series of papers, of which six sections have already been published in the Transactions of the Royal Society of Edinburgh.

It commences with some articles supplementary to the first six sections, and intended to apply to the theoretical principles contained in them to the extensive and precise experimental data which have been obtained in the course of the last two years.

Article 65 relates to the *Absolute Thermometric Scale* and to *Thermodynamic Functions.* The *Absolute Thermometric Scale* is a scale, the temperatures on which, according to one definition, are proportional to the actual quantity of energy possessed by any given substance in the form of heat, divided by the real specific heat of the

substance, a constant co-efficient, and, according to another definition, are proportional to the tendencies of heat to disappear in producing mechanical effects. These definitions are substantially equivalent. The recent experiments of Messrs Joule and Thomson have confirmed the anticipation, that absolute temperatures, as thus defined, agree with those measured by the variation of pressure of a perfect gas; they have also proved, what could only be conjectured before, that the absolute zeros of heat and of gaseous pressure sensibly coincide. The author, from a revision of M. Regnault's experiments on the elasticity of gases, concludes the most probable value of the absolute temperature of melting ice to be—

$$274^\circ \text{ Centigrade} = 493^\circ{\cdot}2 \text{ Fahrenheit.}$$

Messrs Joule and Thomson, from their experiments on the cooling of gases by free expansion, deduce the value—

$$273^\circ{\cdot}7 \text{ Centigrade} = 492^\circ{\cdot}66 \text{ Fahrenheit.}$$

The difference between those values is practically inappreciable.

A *Thermodynamic Function* is a function of the condition of a substance, such that the heat absorbed by the substance during any small variation of condition represented, in units of work, by the product of the corresponding variation of the thermodynamic function into the absolute temperature. A thermodynamic function consists of two parts. The first is connected with the heat stored up as *actual heat* in the substance, and is simply the product of the real specific heat by the hyperbolic logarithm of the absolute temperature. The second is what has been employed in the previous sections of the paper, and in a paper on the centrifugal theory of elasticity, under the name of *Heat-potential*, being a function the product of whose variation into the absolute temperature represents heat converted into mechanical work.

The complete value of the thermodynamic function for a given substance is,

$$\Phi = \mathfrak{k} \text{ hyp. log. } \tau + \int \frac{dP}{d\tau}\, dV,$$

where $\mathfrak{k}$ is the real specific heat, τ the absolute temperature, P the pressure, and V the volume; and the fundamental equation of the mechanical action of heat, previously given in various forms, may be expressed as follows:—

$$d \cdot \mathrm{H} = \tau \, d \cdot \Phi$$

where $d\cdot\mathrm{H}$ is the quantity of energy required, in the form of heat, to produce the variation $d.\Phi$.

In article 65·*a*, a new form of the thermodynamic function is pointed out, in which the *pressure* and absolute temperature are taken as independent variables instead of the *volume* and absolute temperature. It is as follows:—

$$\Phi = \left(k + \frac{\mathrm{P}_0 \mathrm{V}_0}{\tau_0} \right) \text{hyp. log. } \tau - \int \frac{d\mathrm{V}}{d\tau} \, d\mathrm{P},$$

and is useful in solving a particular class of questions. P_0 and V_0 are respectively the pressure and volume of the given substance at the absolute temperature τ_0 in the state of perfect gas.

In article 66, the constants in the formulæ deduced from the hypothesis of molecular vortices for the elasticity of *carbonic acid gas* are revised, and adapted to the corrected position of the absolute zero; the result being expressed by the following very simple law:—

The diminution of the elasticity of carbonic acid gas, produced by the mutual attraction of its particles, varies directly as the square of its density, and inversely as its absolute temperature.

These constants are determined solely from the experiments of M. Regnault on the increase of pressure between 0° and 100° Centigrade of carbonic acid gas of constant density, and in the specific gravity and specific heat of the gas. The results of the formulæ are then compared, and found to agree most closely with those of the following sets of experiments:—

1. Those of M. Regnault, on the expansion of carbonic acid gas at constant pressure.

2. Those of M. Regnault, on the compressibility of carbonic acid gas.

3. Those of Messrs Joule and Thomson, on the cooling of carbonic acid gas by free expansion. The results of the last set of experiments were *anticipated* by means of the formula.

General Formula and Constants for Carbonic Acid Gas.

$$\frac{\mathrm{PV}}{\mathrm{P}_0 \mathrm{V}_0} = \frac{\tau}{\tau_0} - \frac{a}{\tau} \cdot \frac{\mathrm{V}_0}{\mathrm{V}} .$$

P pressure in lb. per square foot, } at the absolute
V volume of one lb. in cubic feet, } temperature τ

P_0 = one atmosphere = 2116·4 lb. per square foot.
V_0 = 8·15725 cubic feet.
P_0V_0 = 17,264 foot-pounds.
a = 1·9 for the Centigrade scale.

Specific Heats of One Pound of Carbonic Acid Gas, at the atmospheric pressure, in units of work per Centigrade degree.

At constant pressure, 300·7 foot-pounds.
At constant volume, 235·9 „ „
Real specific heat, 235·0 foot-pounds.

In article 67, the constants, as determined by Messrs Joule and Thomson, of a formula of the same class for *atmospheric air*, but involving a more complicated function of the reciprocal of the temperature, are adapted to the position of the absolute zero adopted in this paper, as follows :—

$$\frac{PV}{P_0V_0} = \frac{\tau}{\tau_0} - \left(a_0 - \frac{a_1}{\tau} + \frac{a_2}{\tau^2}\right)\frac{V_0}{V}$$

$$P_0V_0 = 26{,}248 \text{ in latitude } 45^\circ.$$
$$26{,}238 \text{ in Britain.}$$
$$a_0 = 0{\cdot}0012811$$
$$\left.\begin{aligned} a_1 &= 1{\cdot}3932 \\ a_2 &= 353{\cdot}9 \end{aligned}\right\} \text{ for the Centigrade scale.}$$

The SEVENTH SECTION of the paper follows, being on the THERMIC PROPERTIES OF VAPOURS.

Article 68 relates to a principle, the first idea of which was imperfectly suggested by Carnot, and more fully developed by M. Clausius. By the aid of improved knowledge of the laws of the mechanical action of heat, it is now stated as follows :—

The latent heat of evaporation, in units of mechanical work, of so much of a substance as fills, in the state of vapour, unity of space more than it fills in the liquid state, is the differential coefficient of the pressure with respect to the hyperbolic logarithm of the absolute temperature.

In article 69 the new form of the thermodynamic function, given in article 65 *a*, is employed to determine the precise law of variation, with the boiling-point, of the total heat of evaporation from a fixed temperature; a law of which the approximate form, applicable to a substance whose vapour is a perfect gas, and very bulky as compared

with its liquid, was first investigated by the author in the third section of the paper.

In article 70 there is deduced from the new form of the thermodynamic function, a law called that of the "*Total Heat of Gazefication,*" which includes, as a consequence, the law of the total heat of evaporation. The *total heat of gazefication* of a given substance, under constant pressure, between two given temperatures, is the heat which must be communicated to the substance in order to convert it from the liquid or solid state at the lower temperature, to the state of *perfect gas* at the higher temperature,—evaporation taking place at the boiling point corresponding to the constant pressure under which the whole operation is performed. When the bulk of the substance (as is the case for all known substances) is very small in the liquid or solid state, as compared with its bulk in the state of perfect gas, *the total heat of gazefication, under constant pressure, between two given temperatures, does not sensibly vary with the pressure.*

This law is of great importance in connection with the employment of super-heated vapours to drive machinery.

In article 71 are given formulæ, founded on the experiments of M. Regnault, for computing the pressures of the vapours of æther, bi-sulphuret of carbon, alcohol above 0° c., water, essence of turpentine above 40° c., chloroform above 70° c., and mercury up to 358° c. The table of constants for these fluids is extracted from a paper read before the British Association in September 1854, and published in the *Philosophical Magazine* for December 1854.

In article 72, it is shown how these formulæ are applied to calculate the *latent heat of evaporation for unity of space.*

In article 73, it is stated, that if the latent heat of evaporation of unity of weight of a fluid be known by experiment for a given temperature of ebullition, and the latent heat of evaporation for unity of space be computed theoretically, the volume of unity of weight of the vapour at the given temperature of ebullition may be calculated from these data. This principle is applied to the latent heats of evaporation, under atmospheric pressure, of æther, sulphuret of carbon, and alcohol, as determined experimentally by Dr Andrews, and of water, as determined by M. Regnault. The results of these calculations are compared with those of computations founded on the chemical composition of the fluids, and the supposition that their

vapours are perfectly gaseous. The following is a summary of the results:—

Fluids	Æther.	Bi-sulp. of Carbon.	Alcohol.	Water.
Boiling points	35° cent.	46°	78°	100°
Volume of one lb. of vapour as computed—	cubic feet.	cubic feet.	cubic feet.	cubic feet.
From latent heat	5·3968	5·4689	9·366	26·36
From composition	5·3874	5·4643	9·900	27·18

In article 74, the close coincidence of the results of the above computations for æther and bisulphuret of carbon is stated to be a confirmation of the principles deduced from the mechanical theory of heat, and also a proof that the vapours of æther and bi-sulphuret of carbon may be treated in practical calculations, without sensible error, as perfectly gaseous, when at pressures not greatly exceeding one atmosphere. The following are the values of some of the constants for these fluids:—

	Æther.	Bi-sulp. of carbon.
P_0V_0	10,110 ft. lb.	9902 ft. lb.
Specific heat of liquid for centigrade scale,	718·4 "	443·3 "
Specific heat of vapour at constant pressure for centigrade scale,	668·4 "	218·9 "

In article 75, the differences between the results of the two methods of computation for alcohol and water are considered as the effects of deviations of the vapours of these fluids from the perfectly gaseous condition,—deviations which in the case of steam have long been anticipated.

On an Inaccuracy (having its greatest value about 1″) in the usual method of computing the Moon's Parallax. By Edward Sang.

When, as in the usual operation, the moon's observed zenith distance is corrected for the effects of atmospheric refraction, the zenith distance so obtained is that of the rectilineal part of the ray of light between the planet and the upper surface of the air; and on applying that correction, as at the Observatory, we do not obtain the direction of the moon as it would have been seen if there had been no atmosphere, but that of a line drawn parallel to the first part of the ray, and therefore passing below the moon. The true direction of a straight line drawn from the observer to the planet, must differ

from this direction by the angle which the curved part of the ray subtends at the moon's centre; and the neglect of this angle may cause a sensible error in estimating the parallax.

It is a well-known property of refraction by concentric strata, that the perpendiculars let fall from the centre of curvature upon the tangent to the path of light are inversely proportional to the indices of refraction of the medium at the two points of contact.

From this property it very easily follows that the sine of the true parallax is obtained by multiplying the sine of the horizontal parallax by the sine of the observed zenith distance, and by the index of refraction of the air at the Observatory.

And if the horizontal parallax given in the almanac, instead of being the half angle under which the earth would have been seen from the moon if there had been no atmosphere, had been the true horizontal parallax, or half the angle which, in the actual state of things, the earth does subtend at the moon,—the true method of computing the parallax would only differ from the common one in the use of the uncorrected instead of the corrected zenith distance.

In the common formula, the multiplier is the sine of the zenith distance corrected for refraction; in the true formula, it is the sine of the uncorrected zenith distance, multiplied by the index of refraction of the air.

For the purpose of obtaining the maximum error of the common formula, it is observed that when the moon is in the horizon, the zenith distances being nearly 90°, have their sines sensibly equal to each other, and that then the true multiplier must exceed the usual one in the ratio of 3405 to 3404,—this ratio being the index of refraction of air in its mean state; wherefore, at the horizon, the parallax, as usually computed, must fall short of the true parallax by one 3404th part of itself.

This ratio holds good for all planets; and it is only in the case of the moon that the error becomes sensible, being then almost exactly one second of an arc.

The following Gentlemen were elected as Ordinary Fellows:—

1. Robert Etheridge, Esq., Clifton, Bristol.
2. John Inglis, Esq., Dean of Faculty.
3. Rev. James S. Hodson, Rector of the Edinburgh Academy.

Monday, 5th March 1855.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read:—

1. On Annelid Tracks in the Exploration of the Millstone Grits in the South-west of the County of Clare. By Robert Harkness, Esq., F.R.S.E., F.G.S., Professor of Geology, Queen's College, Cork.

The author remarks that the existence of Annelida during the Palæozoic formations is manifested in two conditions. In the one, we have the shelly envelope which invests the order Tubicola, in the form of Seapolites; and in the other, the tracks of the orders Abranchia and Dorsi-branchiata are found impressed on deposits which were, at one time, in a sufficiently soft state to receive the impressions of the wanderings of these animals.

Among the strata which have hitherto afforded annelid tracks, those which, in the county of Clare, represent a portion of the equivalents of the Millstone Grit, contain such tracks, in their most perfect state of preservation in great abundance; and these strata also furnish evidence concerning the circumstances which prevailed during their deposition.

The locality of these strata is the neighbourhood of Kilrush, on the banks of the Shannon, in the southern portion of the county. Here the deposits consist of strata which have a flaggy character; and these have been extensively wrought at Money Point, about four miles east from Kilrush, and they supply the flags which are commonly used in the towns of the south of Ireland. The beds vary somewhat in their nature, and with this circumstance they present different phenomena.

The annelid tracks occur in three conditions. When they are in their most perfect state, in the faces of the higher flags, which are of a greenish gray colour, they have the form of meandering tracks, about half an inch across, and their margins crenated. A distinct raised line traverses the centre of these tracks, and the interval between this line and the crenations is marked by a succession of other

lines at right angles to the centre one; and these seem to have had their origin in the rings of the body of the annelid.

The nature of the tracks as they occur in the lower flags, which are dark-coloured, is somewhat different. On the upper surfaces of these they appear also in the form of sinuous furrows, about the same width as the more perfect tracks of the higher flags. Here, however, they rarely present crenations, being regular on their margin, and having, in many instances, the impression of the ventral arch distinct.

The various appearances of the tracks, and the nature of the strata with which these are associated, furnish some important information concerning the conditions which obtained when this portion of the Millstone Grit series was being deposited. The tracks, from their various states of perfection, indicate that, in some instances, the mud which now constitutes these flags had been in different states, as concerns consolidation, at the time when it was traversed by these animals. It sometimes appears to have been in a state so saturated with water that it assumed a pasty condition, partly flowing in upon the tracks after these had impressed its surface, and obliterating the markings of the cirri. At other times it seems to have been sufficiently consolidated to afford the requisite conditions for more perfect tracks, as in the case of the higher greenish-gray flags.

The animals which impressed these Irish flags appear to have been widely different from those which have burrowed in the deposits which now form the flags of the lower portion of the Lancashire coal-field, since, in these latter, neither the entrance into the burrows nor the burrows themselves, equal the annelid burrows of the flagstone of Clare; the former having only a diameter of one-fifth of an inch, and being apparently round, while the latter are half an inch in breadth, and have their form flattened longitudinally, which gives to them, on transverse section, the lenticular shape already referred to. From their crenulated margins, which would indicate that the cirri were more perfectly developed in the annelids to which we owe these tracks, it would seem that they are more nearly allied to those which have impressed the strata of the older formations, than to such as have left their markings on the English carboniferous deposits; and if we adopt the general appellation of Sir Roderick Murchison, they might be considered as the carboniferous type of the ancient *Nerites*, and be designated *Nerites carbonarius*.

2. On Superposition. By Professor Kelland.

The object of this paper was to defend the method of demonstration employed by Euclid from some of the charges which have been at various times brought against it. In particular, it was shown that the method is not deficient in variety of demonstration of the same fact. This position was illustrated by the exhibition of twelve totally different demonstrations of the problem, "To cut three-fourths of a square into four pieces which shall form a square."

3. On the Colouring Matter of the Rottlera tinctoria. By Professor Anderson, M.D., Regius Professor of Chemistry in the University of Glasgow.

The Rottlera tinctoria is a large tree which is found distributed over the whole Indian peninsula, and is particularly abundant in the hill jungles of Mysore, Canara, and Malabar. The fruit, which is about the size of a pea, is covered with curious stellate hairs and red glands, which are easily separated by rubbing, and form without further preparation the colouring matter which is sold in the bazaars. It is a perfectly uniform brick-dust coloured powder, which repels water, and is scarcely soluble in that fluid. Alcohol and ether extract a red colouring matter, as do also the alkalies and their carbonates. A proximate analysis showed it to contain—

Water,	3·49
Resinous colouring matters,	78·19
Albuminous matters,	7·34
Cellulose, &c.,	7·14
Ash,	3·84
	100·00

The colouring matters consist of at least three different substances.

1. A crystallizable matter extracted by ether, to which the author gives the name of Rottlerine. It forms a mass of yellow crystalline scales, having a fine satiny lustre. Insoluble in water, sparingly soluble in alcohol, and readily in ether. It dissolves in alkaline solutions with a deep red colour, but does not form definite compounds with the metallic oxides. It is decolorized by bromine with the pro-

duction of a substitutive product which does not crystallize, and cannot be obtained pure. Its analysis gave as the mean of four closely concordant experiments—

		Mean.	Calculation.		
Carbon,	.	69·112	69·47	C_{22}	132
Hydrogen,	.	5·550	5·26	H_{10}	10
Oxygen,	.	25·333	25·27	O_6	48
		100·000	100·00		

corresponding with the formula $C_{22}\,H_{10}\,O_6$; but the impossibility of forming compounds renders it impossible to ascertain whether this correctly represents its constitution.

2. When the colouring matter is boiled with alcohol the phenomena are materially different; for the filtered solution deposits, on cooling, a pale flocky amorphous substance, which is obtained pure by repeated crystallization. It is insoluble in water, readily soluble in hot, sparingly in cold alcohol, and scarcely at all in ether. Its analysis gave results which agree with the formula $C_{40}\,H_{34}\,O_8$.

3. The red alcoholic solution from which the flocky matter has been separated leaves an evaporation or dark red amorphous resin, melting at 212°. It gives a red precipitate with acetate of lead, but the compound could not be obtained of definite composition, and it seems not improbable that the resin may be a mixture of several different substances. The author found the proportion of oxide of lead to vary between 18·67 and 34 per cent., according to the conditions under which the precipitation was effected. The resin, on analysis, gave results which agree pretty well with the formula $C_{60}\,H_{30}\,O_{14}$, which is in accordance with the lowest proportion of oxide of lead obtained from its compound, but none of the other results can be brought into relation with it.

The colouring matter of the Rottlera belongs to the class of substantive dyes, and does not require the intervention of a mordant. It gives a very fine flame colour on silk, but to calico, with or without mordants, it gives only a pale fawn colour, entirely devoid of beauty. The author considers it worth the attention of silk dyers in this country.

The following Donations to the Library were announced :—

Journal of the Asiatic Society of Bengal. No. V., 1854. 8vo. —*From the Society.*

The Quarterly Journal of the Geological Society. Vol. X., Part 4. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVII., Part 4. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. No. 48. (N.S.). 8vo. —*From the Society.*

Catalogue of Stars near the Ecliptic, observed at Markree, during the years 1852, 1853, and 1854, and whose places are supposed to be hitherto unpublished. Vol. III. 8vo.—*From the Royal Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. XIX., No. 55. 8vo.—*From the Editors.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Mathematisch-Naturwissenschaftliche Classe. Bd. XII., Heft 5; Bd. XII., Heft 1 und 2, 8vo.

Register zu den ersten X. Bänden der Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe. 8vo.

Jahrbücher der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Von Karl Kreil. (Herausgegeben durch die Kaiserliche Akademie der Wissenschaften). II. Bd. 4to.—*From the Academy.*

Annalen der Königlichen Sternwarte bei München. VI. Bd. 8vo.

Magnetische Ortsbestimmungen an verschiedenen Puncten des Konigreichs Bayern und an einigen auswärtigen Stationen. I. Theil. 8vo.—*From the Observatory.*

Magnetische Karten von Deutschland und Bayern. Von Dr J. Lamont. Fol.—*From the Author.*

Transactions of the Linnæan Society of London. Vol. XXI., Parts 2 and 3. 4to.

Monday, 19*th March* 1855.

COLONEL MADDEN, Councillor, in the Chair.

The following Communications were read:—

1. Experiments on Colour as perceived by the Eye, with Remarks on Colour-Blindness. By James Clerk Maxwell, Esq., B.A., Trinity College, Cambridge. Communicated by Professor Gregory.

These experiments were made with the view of ascertaining and registering the judgments of the eye with respect to colours, and then, by a comparison of the results with each other, by means of a graphical construction, testing the accuracy of that theory of the vision of colour which analyses the colour-sensation into three elements, while it recognises no such triple division in the nature of light, before it reaches the eye.

The method of experimenting consisted in placing before the eye of the observer two tints, produced by the rapid rotation of a system of discs of coloured paper, arranged so that the proportions of each of the component colours could be changed at pleasure. The apparatus used was a simple top, consisting of a circular plate on which the coloured discs were placed, and a vertical axis. The discs consisted of paper painted with the unmixed colours used in the arts. Each disc was slit along a radius from centre to circumference, so that several could be interlaced, so as to leave exposed a sector of each. The larger discs, about 3 inches diameter, were first combined and placed on the disc, and the smaller, about 1¾ inches diameter above them, so as to leave a broad ring of the larger discs visible.

When the top was spun the observer could compare the resulting tint of the outer and inner circles, and by repeated adjustment, perfect identity of colour could be obtained. The proportions of each colour were then ascertained, by reading off on the circumference of the top, which was divided into 100 parts. As an example, it was found on one occasion, that,—

$$\left.\begin{array}{r} \cdot 37 \text{ Vermilion,} \\ + \cdot 27 \text{ Ultramarine,} \\ + \cdot 36 \text{ Emerald green,} \end{array}\right\} = \left\{\begin{array}{l} \cdot 28 \text{ White} \\ + \cdot 72 \text{ Black} \end{array}\right.$$

By experiments on various individuals, it was found (1.) that a good eye could be depended upon within two of these divisions, or hundredths, at most; and that by repetition of experiments the *average* result might be made much more accurate.

(2.) That the difference of the results of experiments on different individuals was insensible, provided the light used remained the same.

(3.) That when different kinds of light were used, or when the resultant tints were examined with coloured glasses, the results were totally changed.

It follows from this that the cause of the equality of the resulting tints is not a true optical identity of the light received by the eye, but must be sought for in the constitution of the sense of sight. The materials for this inquiry are to be found in the equations of colour of which the above is an example, and these are to be viewed in the light of Young's theory of a threefold sensation of colour.

The first consequence of this theory is, that between any *four* colours an equation can be found, and this is confirmed by experiment.

The second is, that from two equations containing different colours a third may be obtained by the ordinary rules, and that this also will agree with experiment. This also was found to be true by experiments at Cambridge which include every combination of five colours.

A graphical method was then described, by which, after fixing arbitrarily the positions of three standard colours, that of any other colour could be obtained by experiments in which it was made to form a neutral gray along with two of the standard colours. In the diagram so formed, the position of any compound tint is the centre of gravity of the colours of which it is composed, their *masses* being determined from the equation, and the resultant *mass* of colour being the sum of the component *masses*. The colour-equations represent the fact that the same tint may be produced by two different combinations. This diagram is similar to those which have been given by Meyer, Hay, and Professor J. D. Forbes, as the results of mixing colours. It is identical with that proposed by

Young, and figured in his *Lectures on Natural Philosophy*. The original conception, however, seems to be due to Newton, who gives the complete theory, with an indication of a construction in his *Optics*.

The success of this method depends entirely on the truth of the supposition that there are three elements of colour as seen by the eye, every ray of the spectrum being capable of exciting all three sensations, though in different proportions. It is at present impossible to define the colours appropriate to these sensations, as they cannot be excited separately. But it appears probable that the phenomena of colour-blindness are due to the absence of one of these elementary sensations, and, if so, a comparison of colour-blind with ordinary vision will show the relation of the absent sensation to those with which we are familiar.

A method was then described, by which one observation by a colour-blind eye was made to determine a certain point representing the absent sensation, which thus appears to be a red approaching to crimson. The results of this hypothesis were calculated in the form of "equations of colour-blindness" between colours which seem to defective eyes identical. These equations were compared with those previously determined from the testimony of two colour-blind but accurate observers, and found to agree with remarkable precision, rarely differing by more than 0·02 in any colour. The effect of red and green glasses on the colour-blind was then described, and a pair of spectacles having one eye red and the other green was proposed as an assistance to them in detecting doubtful colours.

2. Notice of the Occurrence of British newer Pliocene Shells in the Arctic Seas, and of Tertiary Plants in Greenland. In a letter from Dr Scoular of Dublin. Communicated by James Smith, Esq., of Jordanhill.

Dr Scoular writes :—

"I have lately had the opportunity of examining a series of fossils from high arctic latitudes, brought home by Captain M'Lintock, R.N. The series in one sense is extensive, as there are Silurian and oolitic shells, and also other fossils of the tertiary times. Among these last there are some things which, I am sure, will be of interest to you. Among the specimens are some recent and living shells

from Baring's Island, of which I will send you a list when I determine the species. In the meantime, I may state with full confidence that the variety called Mya udevallensis, so common a fossil with us and in Sweden, is still a living species at Baring's Island. The truncated form of the shell, and the palliar impressions, are those of the M. udevallensis, and not those of the modern M. truncata. On the truth of this you may fully rely, and also that the shells were taken with the animal in them.

"In the collection there are also some fossil plants from Greenland. They are not, however, carboniferous; but to my surprise tertiary, and of the same character as those of the Mull formation. I could not find any difference between them and the fossil leaves from Mull, but I cannot at present command the paper by the Duke of Argyll; however, I have not the smallest doubt of the identity of the formation and species."

The following Gentleman was elected an Ordinary Fellow:—

Dr Wyville Thomson, Professor of Geology, Belfast.

Monday, 2d April 1855.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1.—Account of Experiments to ascertain the amount of Prof. Wm. Thomson's "Solar Refraction." By Prof. C. Piazzi Smyth.

After alluding to the excessive difficulty of ascertaining the presence and nature of a resisting medium in space, by planetary or cometary perturbations, the author reminded the meeting of the statements made in those rooms last year, that one of the consequences to which the dynamical theory of heat had led him, was the necessity of the existence of a medium filling space; that such medium was but an extension of our own atmosphere, and must experience a condensation in the neighbourhood of the sun; and that there must consequently arise a certain refraction of any heavenly body seen through such medium.

Impressed, therefore, with the importance of endeavouring to get by these means some further light in regard to the long vexed ques-

tion of the resisting medium, Professor Smyth had instituted, during the last summer, a series of observations on stars in the neighbourhood of the sun. Atmospheric difficulties had, however, prevented much being done; and in the whole history of the observatory, but one group of observations available for the purpose in view had been found. This, on being subjected to special calculation, has given two results, both confirmatory, and indicating an amount of solar refraction of $0^{s}\cdot04$ in right ascension, at a distance of 12 minutes of time from the sun.

2. On the Extent to which the Theory of Vision requires us to regard the Eye as a Camera Obscura. By Dr George Wilson.

The object of this communication was to combat the current theory of vision, as exercised by vertebrate animals, in so far as it teaches that the light which reaches the retina from without, thereafter passes through that membrane, and is absorbed by the pigment of the choroid behind it.

The author first enumerated the arguments adduced in favour of this view, such as,

1. The difficulty in assigning any other use for the choroid than that of absorbing the light which falls upon it.

2. The advantages known to result in artificial cameræ obscuræ from the internal darkening of their walls.

3. The confusion which must attend visual perception, if the rays by which objects are seen are reflected several times across the chamber of the eye, so as to repeat, on different points of the retina, the image of a solitary object.

4. The painful and imperfect vision known to characterize the human albino.

The author then proceeded to state that a mass of evidence, daily accumulating, had established, beyond question, the certainty that light is reflected from the anterior layers of the retina and from the choroid, and so abundantly, that oculists take daily advantage of the fact, to examine, by means of this light, the deeper internal structures of the eye.

This organ, accordingly, cannot be regarded otherwise than in a limited sense as a camera obscura, and the arguments in favour of

the opposite belief were shown to furnish no substantial support of the current opinion. Thus, the eyes of albino *animals* were found to exercise vision perfectly, although destitute of *pigmentum nigrum;* and the presence of the *tapetum lucidum*, which acts like a concave metallic reflector in the eyes of many creatures, was shown to furnish no obstacle to sight, which, on the other hand, it rendered more acute when light was feeble. The supposed cross reflection of light within the eye was also shown to be a phenomenon which could rarely occur so as to disturb vision, since the majority of the reflected rays would simply retrace the course which they took on entering the eye, and pass out through the pupil as they passed in through it; and the few which diverged so much as to fall on the back of the iris, the ciliary processes and the anterior lateral surface of the choroid, would be caught upon the darkest and least reflecting portion of the interior of the eye, and undergo in greater part absorption, whilst such as were not thus stopped, and those which underwent lateral reflection from the bottom of the eye, would be irregularly dispersed over the entire retina, and only lessen its general sensitiveness without repeating the images of objects on single points of its surface.

The author finally urged that the reflection of light from the bottom of the eye served important ends, especially in the lower animals. Those ends he held to be;—

1. The return from the choroid of light through the retina, so as to double the impression on the latter.

2. The reflection of light on external objects, which was best seen in creatures whose eyes are provided with *tapeta lucida*, and acted alike as an assistance to them in finding their food, and in the case of carnivorous nocturnal and marine animals, to their prey in escaping from them.

In the human subject, it was contended that, in very faint light, reflection from the bottom of the eye would assist vision, and that the known delicacy of visual perception, which characterised those who had been long imprisoned in dark chambers or dungeons, afforded an example of such assistance. The author also insisted on the fact, that, as the reflected light is always coloured, so as in the human eye to be bright red, yellowish-red, or brownish-red, and in different eyes to a different degree; and as we add from our eyes coloured light to every object we gaze at, no two persons see the same colour alike, or will exactly agree in matching tints. The existence

and importance of such a chromatic personal equation was dwelt on at some length.

3. Researches on the Amides of the Fatty Acids. By Thomas H. Rowney, Ph.D., Assistant to Dr Anderson. Communicated by Dr Anderson.

The author in this paper gives the details of an examination of the compounds obtained by the action of ammonia on some of the oils and fats.

The method employed was to mix one volume of the oil, two volumes alcohol, and four volumes of strong aqua ammoniæ in a stoppered bottle, and placing it in a moderately warm situation, the stopper being tied down. Occasional agitation is required. After a time, varying with the oil employed, there is formed a whitish solid matter, which increases in amount as the oil diminishes. Finally, the whole becomes nearly solid.

The mass is collected on a cloth filter, washed with a little water, and squeezed, and the residue dissolved in warm alcohol; the crystals deposited on cooling are washed first with dilute spirit, then water, and again expressed, and this was repeated till a resinous matter was removed, which adheres obstinately to the product.

The amides thus formed, when pure, are white, and permanent in the air, but if any of the resin be present, they soon become yellow and resinous.

The quantity obtained from different oils varied much. The drying oils yield less of the amides and more resin than the fat oils.

The oils hitherto examined are almond oil, linseed oil, poppy oil, cod-liver oil, seal oil, and croton oil, besides almond oil and castor oil after solidification by nitrous acid.

The author describes the properties and gives the analytical details of the amides thus produced, and the results are summed up as follows:—

Linseed oil, Poppy oil, and Croton oil	yield margaramide ;	
Almond oil and Seal oil	yield oleamide ;	
Castor oil	yields ricinolamide ; and	
Almond oil and Castor oil	after solidification by nitrous acid, yield	elaidamide and palmamide ;

Which two latter compounds are isomeric with oleamide and ricinolamide.

The melting points of these amides were found as follows :—

Margaramide, ...	103° C.	(60° C. Boullay)
Palmamide and Elaidamide,	94° C.	
Oleamide, ...	82° C.	

The author considers the melting points ascribed to ricinolamide (66° C.) and isocetamide (67° C.), by Boullay, are below the truth.

The researches of the author are not yet completed, and the results of experiments now in progress will be given on a future occasion.

Monday, 16*th April* 1855.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read :—

1. Notice of some new Forms of British Fresh-Water Diatomaceæ. By William Gregory, M.D., F.R.S.E., Professor of Chemistry.

The author stated that he had examined, more or less minutely, nearly 300 fresh-water gatherings, and that he had found in these very nearly all the known British species, besides a number not yet described. He mentioned that, from the want of figures, it was often difficult to know whether a form were new or not. Thus, *Pinnularia latestriata*, found by the author two years since in the Mull earth, had been considered as a new species by all British naturalists, as well as several foreign ones; yet in Ehrenberg's last work, "Mikrogeologie" it is figured as *P. borealis*, and as having been described by Ehrenberg ten or twelve years ago. The papers of that author, in the Berlin Reports and Transactions, are not generally accessible. Ehrenberg describes this species as being one of two found scattered in every part of the world, and in almost every locality, more uniformly than any others; which is confirmed by the author's observations in this country. Yet, although a remarkable and conspicuous form, it had escaped notice in Britain till 1852. This shows the necessity of minute search, without which the scattered forms are sure to be overlooked.

The new forms were described in three sections.

I. Species figured by foreign authors, but new to Britain.

1. Eunotia tridentula.
2. Navicula follis (Trochus ?) Ehr.
3. „ dubia, Kütz.
4. „ Bacillum, Ehr.
5. Pinnularia megaloptera, Ehr.
6. „ dactylus, Ehr.
7. „ nodosa, Kütz.
8. „ pygmæa, Ehr.
9. Stauroneis Legumen, Kütz.
10. Stauroneis ventricosa, Ehr.
11. Cocconema cornutum, Ehr.
12. Gomphonema subtile, Ehr.
13. Melosira distans, Ehr.
14. Navicula amphigomphus, Ehr., and
15. „ dilatata, Ehr., possibly varieties of Navicula dubia, not figured by the author.

II. New Species, observed by others, nearly about the same time as by the author, and named by the Rev. Professor Smith, but still MS. species.

16. Navicula apiculata, Sm.
17. „ rostrata, Sm.
18. „ scutelloides, Sm.
19. Mastogloia Grevillii, Grev.
20. Pinnularia hemiptera, Sm. (not figured.)
21. Navicula sufflata, Sm. (Auvergne. Found in Britain by the author. Not figured.)

III. Species now first described and figured.

22. Cymbella (?) sinuata. W. G.
23. „ turgida, W. G.
24. „ obtusa, W. G.
25. „ Pisciculus, W. G.
26. „ Arcus, W. G.
27. Navicula cocconeiformis, W. G.
28. „ lacustris, W. G., do. β.
29. „ lepida, W. G., do. β.
30. „ bacillaris, W. G.
31. „ incurva, W. G.
32. „ longiceps, W. G.
33. Pinnularia gracillima, W. G. (vaciva, Sm.)
34. Pinnularia linearis, W. G.
35. „ biceps, W. G.
36. „ digitoradiata, W. G.
37. „ Elginensis, W. G.
38. „ globiceps, W. G.
39. Stauroneis obliqua, W. G.
40. „ dubia, W. G.
41. „ ? ovalis, W. G.
42. Surirella tenera, W. G.
43. Gomphonema insigne, W. G.
44. „ ventricosum, W. G.
45. „ Sarcophagus, W. G.
46. „ æquale, W.G.

The following numbers refer to figures of the varieties of Navicula elliptica, Kütz:—

47. Navicula elliptica, Kütz.
48. „ „ var. β
49. Navicula elliptica, var. γ
50. „ „ var. δ

The whole of the above species, with the few exceptions above noted, were illustrated by highly finished drawings, made from nature by Dr Greville, and enlarged to a scale of 10,000 times the natural linear dimensions.

The author concluded by making some observations on the distribution of fresh-water Diatoms, and showed by various examples that it is often quite easy to determine the characters of a species, if these be well marked, even when it occurs sparingly or scattered, and that when a form is once noticed, we are pretty sure to find it soon after in greater abundance. To show the value of minute search, he stated that although most of the above new species occurred in several gatherings, yet in point of fact, nearly the whole of them had been

observed in a detailed exploration of only four gatherings, those, namely, from Elgin, Elchies, Lochleven, and Duddingston Loch. Nay, he had found them all, except only one or two, by degrees, in the Lochleven gathering alone, and a very large proportion of them in each of the three others. So that, if his observations had been confined to these four gatherings, or even to that of Lochleven, it would have been possible to recognise and distinguish nearly all the species here mentioned.

The above list of forms is entirely exclusive of those very numerous and varied ones, occurring, however, in many of the gatherings examined by the author, as above described, which he has elsewhere united together, described, and figured, under the name of Navicula varians.

The figures of Navicula elliptica, Kutz., and its very striking varieties, as the author had observed them in the study of these gatherings, were referred to, in order to prove that certain species vary not only in form or outline, as in the case of Navicula varians, Pinnularia divergens, and many others, but also in general aspect, in the number of striæ in $\frac{1}{1000}$th of an inch, comparing two frustules of equal size, in the structure of the median line, and in that of the central or terminal nodules.

2. On Glacial Phenomena in Peebles and Selkirk Shires. By Robert Chambers, Esq., F.R.S.E., &c.

In this short paper, the author presented facts, from which he thought himself entitled to infer that the Silurian mountain tract of southern Scotland falls entirely into his views regarding ancient glacial operations in the country generally, as expounded in a paper read to the Royal Society of Edinburgh, in December 1852, and published in the *Edinburgh New Philosophical Journal* for April 1853. He showed that the compact boulder clay, which he regards as the detritus of the early and general *glaciation* of the country, exists in the valleys of this district, and in passes amongst the hills, up to those of Glenlude and Tweedshaws, which are respectively 1152 and 1352 feet above the mean level of the sea. Striated boulders from Glenlude and Tweedshaws were brought before the Society. The rounded form of the hills, and the horizontal *mouldings* or *flutings* which are seen along the faces of many of them, he con-

siders as other memorials of the operation in question. The nature of the rocks is unfavourable for the preservation of smoothed and striated surfaces; but Mr Chambers had found one such on the border of St Mary's Loch in Selkirkshire, 800 feet above the sea. On the assumption that the hills had been shorn and rounded by moving ice, it appeared from the high inclination of the strata, as exhibited in a copy of Professor Nicol's section of the district, that the amount of denudation fully equalled the remarkable examples adduced by Professor Ramsay in regard to South Wales and the Mendip hills. Finally, Mr Chambers described an example of the later and limited operations of ordinary glaciers, in the elevated moor of Loch Skene, a tarn formed and retained by a moraine.

3. Preliminary Notice on the Decompositions of the Platinum Salts of the Organic Alkalies. By Thomas Anderson, M.D., Regius Professor of Chemistry in the University of Glasgow.

The following pages are intended merely as a preliminary notice of an investigation, which has occupied me for some time past, and which, though still too incomplete for publication in full, is sufficiently advanced to render obvious the general character of the results, although, from the extensive and elaborate nature of the inquiry, a very considerable time must elapse before it is complete in all the requisite details.

It has been known for some years that the platinum salts of the organic alkalies are decomposed when boiled with excess of bichloride of platinum; and with narcotine, the only one as yet examined, the action is a true process of oxidation, yielding results similar to those obtained by treating the base with peroxide of manganese or nitric acid. The present investigation refers to the pure platinum salts, which undergo an entirely different decomposition, the nature of which is materially dependent on the stability of the base. Having observed that the decomposition was more precise and definite when the less decomposable bases were employed, and apparently calculated to afford the key to the more complex changes, which occur in other cases, I have hitherto directed my attention more particularly to pyridine and picoline, which are so remarkable for their stability,

and especially for the obstinacy with which they resist the action of oxidizing agents.

When the platinum salt of pyridine, carefully freed from excess of bichloride of platinum is dissolved in hot water, and the solution kept steadily boiling for some hours, a fine sulphur yellow crystalline powder begins to appear. After five or six days' continuous boiling the whole of the platinum salt is converted into this substance, but if the powder be filtered off before the change is complete, the mother liquid on cooling gives a deposit of fine golden-yellow scales resembling iodide of lead.

The yellow powder is insoluble in water and acids, and is decomposed by potash slowly in the cold, more rapidly on boiling, with the evolution of pyridine. It is the salt of a platinum base, analogous to platinamine, to which I give the name of platinopyridine. Its analysis gave—

	Expt.	Calculation.		
Carbon, . . .	24·30	24·12	C_{10}	60·
Hydrogen, . . .	2·14	2·01	H_5	5·
Nitrogen, . . .	...	5·65	N	14·
Chlorine, . . .	28·56	28·54	Cl_2	71·
Platinum . . .	39·60	39·68	Pt	98·7
		100·00		248·7

It is therefore a bihydrochlorate of platinopyridine, with the formula $C_{10}\ H_8\ Pt\ N + 2\ H\ Cl$, and the decomposition which yields it consists simply in the expulsion of an equivalent of hydrochloric acid, as represented by the equation

$$C_{10}\ H_5\ N,\ H\ Cl\ Pt\ Cl_2 = C_{10}\ H_3\ Pt\ N + 2\ H\ Cl + H\ Cl.$$

The equivalent of hydrochloric acid escapes with extreme slowness, but the change may be much facilitated by the addition of a sufficient quantity of pyridine to combine with it, although an excess must be carefully avoided, as it produces a different decomposition, to be afterwards described.

Platinopyridine cannot be separated from the bihydrochlorate by alkalies, but when boiled with salts of silver, the corresponding salts of the base are obtained. The decomposition, however, is very slowly effected, and certain changes occur which I am not yet in a condition satisfactorily to explain. When the hydrochlorate is boiled with two equivalents of sulphate of silver, it gradually loses its

colour, and the yellow solution produced contains the sulphate of platinopyridine, which is extremely soluble in water, and dries up into a gummy mass on evaporation. Considerable difficulties have been encountered in obtaining the salts of platinopyridine in a state fitted for analysis, and the only one which has given satisfactory results is the chromate, which is obtained on adding bichromate of potass to the sulphate, in the form of a fine orange-red precipitate, having the formula $C_{10}\,H_8\,Pt\,N\,HO\,CrO_3$.

When the bihydrochlorate of platinopyridine is boiled with two equivalents of sulphate or nitrate of silver for a shorter time than is requisite for its complete decomposition, and the chloride of silver collected on a filter, washed and treated with ammonia, it leaves behind a yellow crystalline matter, generally in small quantity. This substance is insoluble, or nearly so, in water, but dissolves in boiling nitric acid, from which it is deposited, on cooling, in beautiful shining plates. It contains chlorine, but I have not yet succeeded in explaining its constitution.

The golden yellow scales produced when the ebullition of the platinum salt of pyridine is stopped before the change into platinopyridine is complete, have a very singular constitution, the analysis giving—

	Expt.	Calculation.		
Carbon, . . .	22·70	23·47	C_{20}	120·
Hydrogen, . .	2·30	2·06	H_{11}	11·
Nitrogen, . . .	...	5·26	N_2	28·
Chlorine, . . .	32·75	33·24	Cl_5	177·5
Platinum, . . .	36·61	36·97	Pt_2	197·4
		100·00		533·9

and its formula is—

$$C_{10}\,H_5\,N\,H\,Cl\,Pt\,Cl_2 + C_{15}\,H_3\,Pt\,N\,2H\,Cl,$$

representing it as a double compound of the original platinum salt and the bihydrochlorate of platinopyridine. I refrain at present from discussing its nature.

When the platinum salt of pyridine is boiled with an *excess* of pyridine, the fluid becomes extremely dark-coloured, and on evaporation to dryness in the water-bath and addition of water, a dark solution is obtained, and a crystalline residue left, which is very sparingly soluble in water, more so in boiling alcohol, and is deposited

on cooling in small needle-shaped crystals. Its composition was found to be—

	Expt.	Calculation.		
Carbon, . .	28·31	28·14	C_{10}	60·
Hydrogen, . .	2·48	2·34	H_5	5·
Nitrogen, . .	...	6·58	N	14·
Chlorine, . .	16·69	16·65	Cl	35·5
Platinum, . .	45·83	46·29	Pl	98·7
		100·00		213·2

This corresponds with the formula $C_{10}H_4PtN + HCl$, which is that of a hydrochlorate of platosopyridine corresponding to the hydrochlorate of platosamine. By treatment with nitrate and sulphate of silver the salts of these acids are produced.

The picoline platinum salt decomposes very slowly, but after eight or ten days' boiling a platinopicoline is produced. If a little picoline be added to the solution, the change is complete in a few hours. The bihydrochlorate is insoluble in water, and the double compound containing that substance in combination with the original salt, and of which the formula is

$$C_{12}H_7NHClPtCl_2 + C_{12}H_5PtN\,2HCl,$$

crystallizes in grains, and is much less soluble than the corresponding pyridine compound. The properties of these substances will be afterwards fully described.

The platinochloride of ethylopyridine is very slowly decomposed by boiling, but eventually a substance is deposited which as yet has given only discordant results. A small quantity of pyridine appears to promote the decomposition, but the most remarkable effect is produced by the addition of ammonia. The solution in this case is completely decolorized by a few minutes' boiling, and it then gives a white precipitate on the addition of carbonate of ammonia. The substance so obtained is very sparingly soluble in water, and almost insoluble in alcohol. Analysis showed it to be Raewski's carbonate, the sesquihydrochlorocarbonate of diplatinamine. The action of ammonia is readily explained by the equation

$$C_{14}H_9NHCl + PtCl_2 + 2HN_2 = N_2H_4PtHCl + C_{14}H_9NHCl.$$

The salt, N_2H_4PtHCl, was separated from the fluid and examined; it appears to be identical with the substance obtained by Gerhardt by the action of ammonia on the platinochloride of ammonium.*

The details of these, and other decompositions, I reserve to a future time; meanwhile I shall content myself with stating that most of the platinum salts examined are decomposed by sufficiently protracted ebullition, although some are extremely stable.

The platinum salt of ethylamine is scarcely changed when boiled alone, but in presence of excess of base, a substance is produced, sometimes in yellow, and at other times in purple crystals, which become yellow at 212°. It appears to be the hydrochlorate of platosethylamine.

The aniline compound is very easily decomposed, but the products do not appear to be definite.

The narcotine compound dissolves in a considerable quantity of hot water, and on boiling the solution at first remains unchanged; after some hours, however, it acquires a brown colour, and, a few minutes' longer boiling, a black precipitate, containing the whole of the platinum, but combined with some organic matter, is deposited. The filtered fluid, on addition of ammonia, gives a precipitate resembling narcotine, but whether it is that base, or a product of decomposition, I have not determined.

The brucine compound is very sparingly soluble, but if boiled with water is at length decomposed, with the production of a black powder; on filtering a red solution is obtained, which deposits a yellow platinum salt on cooling. It is possible, however, that this may be merely a portion of the original salt, for as soon as the undissolved portion had become black I filtered the solution.

I shall not at present enter on the consideration of the inferences to be drawn from this investigation, further than to observe that it is likely to modify to some extent certain of the views now entertained regarding the constitution of the bases. In the third part of my investigation of the products of the destructive distillation of animal substances, I have shown that pyridine and picoline, by taking up a single atom of the alcohol radicals, are converted into fixed bases, so that according to the ordinarily received opinion, they are nitryl bases in which the whole of the hydrogen is replaced by these

* Comptes Rendus des Travaux Chimiques, 1849, p. 113.

different radicals. The production of the platinum bases, however, shows that they do still contain replaceable hydrogen, so that either the formation of a fixed base by the addition of one equivalent of a radical does not prove that they are nitryl bases, or the received opinion regarding the constitution of the platinum bases must undergo some modification.

It is clear that at present we cannot attempt any explanation of these apparently anomalous results; but I am now engaged examining the decompositions of the platinum salts of amide and nitryl bases containing known radicals, which will probably lead to their correct explanation.

4. On the Volatile Bases produced by Destructive Distillation of Cinchonine. By C. Greville Williams, Assistant to Professor Anderson, Glasgow University.

In this paper the author shows that Cinchonine by distillation with potash, undergoes a very complex decomposition, and that instead of yielding one base, as has hitherto been supposed, gives at least seven.

The mode of research at first adopted was to convert the basic liquid into platinum salt, and separate the bases by fractional crystallization in the manner described in his paper "On the Presence of Pyridine in the Naphtha produced by destructive distillation of the Bituminous shale of Dorsetshire."*

The experiments made in this manner, indicated that several substances were present, but it was evident that to decide the question, a very large amount of material would be required; the author therefore subjected 100 ounces of cinchonine to distillation with potash, and thus obtained sufficient of the basic oil to enable him to effect twelve complete fractionations, involving at least 240 distillations.

Runge's Pyrrol was present in the crude bases, and was removed by protracted boiling of the acid solution.

The bases were procured free from water by digestion with potash. The following fractions were then analysed.

Fraction boiling at 310° *F.* The basic liquid on analysis gave numbers exactly agreeing with the formula,

$$C^{14}\ H^{9}\ N,$$

* Philosophical Magazine, Sept. 1854.

which is that of Lutidine, a base which has, as yet, only been twice observed before, it having been discovered in Dippel's animal oil by Dr Anderson, and found soon after in Shale Naphtha by the author of the present paper. Pyridine and picoline were also found by fractionally crystallizing the platinum salts obtained about this point in the earlier distillations, but the quantity present was extremely small.

Fraction boiling between 350° *and* 360° *F.* This fraction was found to consist of collidine, a platinum salt giving on combustion numbers agreeing closely with the theoretical values. Collidine was also found in fractions boiling as high as 380° to 390°.

Fraction boiling between 410° *and* 420° *F.* Five analyses of platinum salts obtained at this point indicated the base present to possess the formula,

$$C^{18} H^{7} N,$$

being the chinoline of Gerhardt. The author proposes in a future paper to compare Chinoline with the Leukoline of Hofmann, with a view of determining the question of their being identical, or merely isomeric. Chinoline forms by far the greater portion of the basic liquid.

Fraction boiling between 510° *and* 520° *F.* This was found to consist of a new base, which the author terms Lepidine, the formula of which, derived from analyses of the double salt with bichloride of platinum, the hydrochlorate, nitrate, bichromate, and also the hydriodate of the amyl compound, is

$$C^{20} H^{9} N,$$

the experimental numbers in each case agreeing closely with those required by theory.

The author states his belief that several bases said to be the sole products of certain reactions, as well as some natural ones, will be found to be mixtures, and he is now examining nicotine with a view to ascertain whether it is a homogeneous body ; he also gives the results of some experiments proving pyrrol to be produced by destructive distillation of many nitrogenous bodies, and concludes with

the following table of the substances analysed by him in the course of the investigation,—

Platinum salt of Pyridine, . .	$C^{10} H^5N, HCl, Pt Cl^2$
„ „ Picoline, . .	$C^{12} H^7 N, H Cl, Pt Cl^2$
Lutidine, ...	$C^{14} H^9N.$
Platinum, Salt of Lutidine, . .	$C^{14} H^9N, H Cl, Pt Cl^2$
„ „ Methyllutidine, .	$C^{16} H^{11}N, H Cl, Pt Cl^2$
„ „ Collidine, . .	$C^{16} H^{11}N, HCl, Pt Cl^2$
„ „ Chinoline, . .	$C^{18} H^7N, H Cl, Pt Cl^2$
Lepidine, ...	$C^{20} H^9N,$
Platinum salt of Lepidine, . .	$C^{20} H^9N, H Cl, Pt Cl^2$
Hydrochlorate of Lepidine, . .	$C^{20} H^9N, HCl.$
Nitrate of Lepidine, . . .	$C^{20} H^9N, NO^5, HO.$
Bichromate of Lepidine, . . .	$C^{20} H^9N, 2Cr O^3, HO$
Hydriodate of Amyllepidine, . .	$C^{30} H^{19} N, HI.$

Monday, 30*th April.*

The VERY REV. PRINCIPAL LEE, V.P., in the Chair.

The following Communications were read:—

1. Remarks on the Coal Plant termed Stigmaria. By the Rev. Dr Fleming.

The author, after noticing the proofs of Stigmaria being the root of Sigillaria, called attention to the external organs, known formerly as the leaves, and more recently as the rootlets of the former. He stated that in the many examples of stigmaria which he had examined, he had never observed these rootlets articulated to the stem by anything resembling a ball-and-socket joint, considering the appearance which had led to this notion as due to shrinkage and state of preservation.

The views of Dr Hooker, as given in his valuable paper on Stigmaria in the "Memoirs of the Geological Survey," vol. ii., p. 437, were next considered. This acute observer, from an examination of a particular specimen, concluded that these rootlets, *within* the body of the stem, form obconical or flaggon-shaped bases, the sum-

mits of which are on a level with the mouths of the cavities in which they are contained.

In the two specimens which Dr Fleming exhibited from the Boghead parrot coal,* it clearly appeared that the rootlets communicated directly with the body or trunk, which in this case had been filled from within, with the pulpy matter of the coal, and had thus entered the tubular rootlets which extended for some distance into the argillaceous matter on the outside. Hence he inferred that the flaggon-shaped bodies noticed by Dr Hooker were the lower portions of the rootlets, not in the inside, but on the *outside* of the stigmaria.

The author next called the attention of the Society to a statement in Dr Traill's paper on Bitumenite published in the last part of the Transactions, vol. xxi., p. 10, by which it appeared that "A very magnificent specimen of stigmaria in bitumenite (the name given to the Boghead Parrot), as thick as the human body, had been deposited by Dr Christison in the University Museum." The unusual dimensions here assigned to stigmaria led the author to inspect the specimen, when it was found to be a sigillaria similar to the one which he exhibited from the same coal.

Dr Fleming next exhibited examples of the different *quantities* of coal produced by stigmaria, sigillaria, favularia, calamite, sternbergia, and lepidodendron, observing that as these plants can furnish coal-making materials *separately*, and as their remains exist in coal, it cannot be denied that, in the *aggregate*, they would be equally productive; nor, with these facts in view, could it be maintained that coal can only be formed from fir or allied woods.

The author then proceeded to observe that in ordinary household coals, such as caking, cherry, or splint, each bed is stratified, and the strata are separated at their *partings* by patches of fibrous anthracite, as if formed from broken portions of woody matter. These partings indicate a recurring intermittency of action, probably arising from *season changes* during the accumulation of vegetable matter in a form analogous to peat. The parrot coals, on the other hand, by the absence of stratification (being merely laminated or slaty parallel with

* This valuable coal was dug and sold from the lands of Boghead, and known as the Boghead Parrot or Gas Coal, years before its existence in the lands of Torbanehill was ascertained, and, therefore, as a designation, has the undoubted claim of priority.

the plane of stratification of the neighbouring sedimentary rocks), indicate a more decidedly simultaneous origin, and appear to have been in the state of disintegrated vegetable matter, mixed more or less with earthy mud, and distributed like the beds of sandstone and clays. That these coals were originally clays into which bituminous matter was injected will not be countenanced by any one acquainted with their structural character, contents and relative position. There is no bitumen in the Boghead parrot, nor any substance analogous to what has been termed ozokerite from Binny Quarry, to which Dr Bennett has referred. The last substance, indeed, melts at a heat considerably below that of boiling water.

The pulpy condition of the original material of the parrot coals, must have been favourable for molecular changes usually termed metamorphic, which may have so far modified the forms and structures of the vegetable tissues as to give them a segregated or concretionary character.

The author concluded by expressing his regret that Dr Traill, after the discussions which have taken place in the Society should have carried his opinion, that the Boghead parrot was a new *mineral species*, to which he has given the name of Bitumenite, so very far as to have published it towards the beginning of the last part of the Transactions already referred to; for the material in question is neither chemically, optically, nor mechanically homogeneous, as demonstrated in the papers of Professors Bennett and Balfour at the close of the same part of the Transactions.

2. On Errors caused by Imperfect Inversion of the Magnet in Observations of Magnetic Declination. By William Swan, Esq.

The direction of the Magnetic Meridian, as indicated by that of a freely suspended magnetized needle will generally be erroneous, unless the magnetic axis of the needle is parallel to its axis of figure; and hence, in order to obtain an accurate value of the magnetic declination, it becomes necessary to take the mean of two observations of the needle, first suspended in its usual position and next inverted. If, however, the inversion of the needle is not accomplished with perfect accuracy, the correction, for want of parallelism between the magnetic axis of the needle, and its axis of figure, will not be complete; and the value of the magnetic declination obtained from the

mean of two observations of the needle, first in its usual position, and then inverted, will be affected with a residual error due to imperfect inversion of the needle. The present investigation refers chiefly to that form of declinometer magnet, in which the magnet is converted into a collimator by attaching to it a lens and cross fibres or a divided glass scale, in the principal focus of the lens.

It is shown that the errors due to imperfect inversion may be computed, provided the magnet is observed, not only in its usual position, and then inverted,—that is turned 180° round its axis,—but also, when turned round 90° and 270°.

Putting δ for the correct reading, for the magnetic meridian on the limb of the theodolite, used in observing the magnet; $\delta_1, \delta_2, \delta_3, \delta_4$, for the readings, when the magnet is turned through 0°, 90°, 270°, 360° respectively; and ϵ for the correction to be applied to the value of the magnetic declination got from the mean of the readings in the erect and inverted positions of the magnet,

$$\delta = \tfrac{1}{2}(\delta_1 - \delta_3) - \epsilon.$$

The value of ϵ in seconds of arc may then be computed with sufficient accuracy by the following formulæ—

$$\tan\beta = \frac{\sin\frac{1}{2}(\delta_1 - \delta_3)}{\sin\frac{1}{2}(\delta_4 - \delta_2)}$$

$$\sin\alpha = \frac{\sin\frac{1}{2}(\delta_1 - \delta_3)}{\sin\beta} = \frac{\sin\frac{1}{2}(\delta_2 - \delta_4)}{\cos\beta}$$

$$\epsilon_1 = \frac{\sin\alpha\cos\frac{1}{2}(\beta_1 + \beta_3)\sin\frac{1}{2}(\beta_1 - \beta_3)}{\sin 1''\sin\psi\cos\frac{1}{2}(\delta_1 - \delta_3)}$$

$$\epsilon_2 = \frac{\sin\alpha\cos\frac{1}{2}(\psi_1 + \psi_3)\sin\frac{1}{2}(\psi_1 - \psi_3)}{\sin 1''\sin\psi_1\sin\psi_3\cos\frac{1}{2}(\delta_1 - \delta_3)}$$

$$\epsilon = \epsilon_1 + \epsilon_2;$$

$$\text{Where } \beta_1 = \beta + \gamma_1;\ \beta_3 = \beta + \gamma_3;$$

$\gamma_1, \gamma_3, \psi_1, \psi_3$ and ψ, being angles found by actual observation.

3. On the Accuracy attainable by means of Multiplied Observations. By Edward Sang, Esq.

On opening any astronomical work of the present day, we are at first startled by, and then familiarized with, the excessive precision of the numbers set down. In our Nautical Almanac, for example,

although referring to a period three or four years subsequent to the date of publication, the declinations of the stars and planets are set down to tenths of a second of arc, and their right ascensions to hundredths of a second of time.

Similarly in tables of the geographical positions of observatories, we find the latitude and longitude often given to the same degrees of precision; an accuracy which would affect to discriminate between the latitudes of the two ends, or the longitudes of the two sides of a dining table.

Yet it is very much to be doubted if any astronomical instrument exist, which, by a single observation, is capable of giving the altitude of a star, or the latitude of a place, true to the nearest second; and it is also very much to be questioned, whether any ear, however practised, has acquired such delicacy of perception as to note the instant of an expected occurrence true to the nearest tenth of a second.

Now, astronomers draw the most important conclusions from the measurements of minute quantities. Thus, the absolute distances of the sun and planets are determined from the measurement of an angle of 8 or 9 seconds, and which is set down as being accurately $8''\cdot5776$, the unimaginable precision of the last figure being obtained by Professor Encke from observations made in 1761, 1769.

The linear velocity of light, again, is computed from observations on an angle of some $40''$; our knowledge of the relative masses of the planets is founded on the measurement of minute disturbances, and our wide guess at the distance of the fixed stars relies on the perception of a single second of annual parallax amid a heap of uncertainties of precession, nutation, and proper motion.

It is then of some importance to inquire into the degree of confidence which ought to be placed in such excessively minute determinations, and to distinguish between that degree of precision to which we have actually attained, and that imaginary exactitude which is the result of arithmetical operations.

The common method of determining any quantity to an extreme degree of precision, is to measure that quantity very often, and then to take the arithmetical mean of the multitude of discordant results, it being understood that some principle of compensation exists which renders the mean more trustworthy than any of the actual observations from which it has been obtained.

It has been plausibly argued against this proceeding that as the

mean rarely coincides with any of its constituents, all the evidence goes to show that it is *not* the true result. Without, however, stopping to examine the logical, I proceed to weigh the logistic, argument which bears upon the matter.

In order to have a case before me, I shall take, as a fair example of this method, the determination of the latitude of Padua by the celebrated astronomer, Giovani Santini, in 1811. His process was to observe the instants when several stars of various declinations reached a fixed altitude; by which means he depended only on the going of his clock and the verticality of the axis of his instrument. From sixteen sets of such observations he obtained the following results with their mean.

I.	45°	23′	56· ″	X.	45°	23′	59·4″
II.	45	24	5·7	XI.	45	23	59·
III.	45	24	4·6	XII.	45	24	4·1
IV.	45	23	56·0	XIII.	45	24	4·4
V.	45	24	7·2	XIV.	45	24	3·0
VI.	45	24	5·2	XV.	45	23	58·5
VII.	45	24	3·1	XVI.	45	24	0·7
VIII.	45	24	3·2				
IX.	45	24	4·5	Medio di tutti	45	24	2·16

Now, on glancing at these numbers, we observe that two of them are no less than 6″·16 below, and one 5″ above the mean; and these variations would seem to show, not that we have obtained a latitude which can be depended upon to the nearest second, but that the observations are not to be trusted to nearer than ten seconds; and amid these disagreements, Signor Santini's concluding remark sounds strangely,

"Si può pertanto stabilire la latudine dell' osservatorio di Padova in numeri rotondi 45° 24′ 2″."

It would seem that, unless these results have been connected together by some law that would insure the compensation of errors, the only conclusion that we are entitled to come to is, that the latitude of the Observatory of Padua is between 45° 23′ 56″ and 45° 24′ 0·7″.

Taking, then, this example as a general type of such proceedings; I observe that there are two distinct sets of cases; viz., those where

a known law of compensation exists; and those in which the separate observations and their errors are independent of each other.

Thus, when we repeat the measurements of an angle upon different parts of a circle, we are certain that, however erroneous the division may be, the entire circumference is 360, and that, therefore, an error of defect in one part, implies one of excess in another part of the limb. Again, if we read at three or five places equidistant from each other, we know that that part of the inaccuracy which arises from the eccentricity of the fittings, is eliminated. Or if we take an altitude face East and then face West, we know that the two errors arising from a misplacement of the zero compensate for each other. But in all those cases where the compensating principle exists, a result from which any of the compensating quantities is excluded, cannot be considered as that of a complete observation; thus an altitude face East, without its complementary altitude face West, could not be used to found upon; and those only in which the compensating principle has had full scope, can be admitted to be observations.

Thus it seems that our attention need only be given to those cases in which no law of compensation is known to exist: of which our example is one.

As there existed no particular reason why one set of stars should have been taken rather than another, Signor Santini might have chanced to make only observations I. and IV., and he would have had strong reason to believe the latitude to be 45° 23′ 56″; or if the weather had permitted him to make only observations III., IX., XII., and XIII., he would have concluded that the true latitude is 45° 24′ 04″. Within the limits of the errors to which the particular class of observations is liable, it is difficult to adduce any argument in favour of one rather than another, in fact, it is a matter of accident, what result is arrived at.

That we may have a clear view of the subject, suppose that, in order to measure a given angle, a circle is used of, say, 30 inches diameter, divided to 10″, and carrying a telescope powerful enough to render an angle of 10″ quite appreciable; suppose also, that the graduation is perfect, and that by the first observation the angle comes out so many degrees, minutes, and say 40″. If we measure the angle again we shall obtain the same result 40″, and if again and again, and again, still the same 40″; and it is quite clear, that

however often we may repeat the observation, the mean will still remain 40". Yet all the while the true angle may be 41, 42, 43, or even 44"; and it would appear that with such an instrument, an infinity of observations could give us no better a result than a single one.

But if I apply to the same purpose a ten-inch circle carrying a twelve-inch telescope with which 10" can only be estimated, and having its graduation pushed somewhat beyond the limits of workmanship, I find my measurements to fluctuate from 20" to 60". Then the advantage of multiplied observations becomes apparent, and twenty operations give us a result different from that given by ten; and if we admit this system of averaging, we are carried to the absurd conclusion that a small instrument gives more exact results than a large instrument does.

In truth, this averaging of multiplied observations is a fallacy; if the results agree, the averaging is useless; if they do not agree, their discordance affords evidence that the means employed are insufficient to procure the accuracy aimed at.

The same remarks apply to time-observations. To observe the meridian passage of a star we note the instant of its appulse to each of the vertical wires, add the results and take the mean, so that if there be a considerable number of wires, great precision is expected. Now, at each wire we can only, and with hesitation, note the time to the nearest tenth of a second. Suppose that we can do so absolutely, and imagine the wires so placed, that the time of passing from the one to the other is exactly a number of tenths. Then, if the true time of appulse to the first wire were, ·04", the observed would differ from the true by .04" at each one of the wires, and the mean would err also by that quantity. Now, there are many declinations which give the interval of passage from wire to wire an exact number of tenths, so that, even supposing the ear perfect to the nearest tenth of a second, there must be many cases in which the average may be ·04" wrong.

Taking into account the various sources of error in the graduation and adjustment of instruments, we can scarcely assume that the declination of any star is known certainly to half a second of arc, or its right ascension to the twentieth second of time; and it appears that the true use of multiplied observation is to guard against blunders in reading off, and to indicate the degree of confidence which is

to be placed in our results. A quantitative statement in any branch of physical science should give, along with the numerical result, the limit or probability of error, and conclusions drawn from such numbers ought to be made with the probabilities of error full in view. Increased exactitude is only to be obtained by improvements in the means of observing.

The subject may be presented in another light. Assuming that there is some unknown influence tending to derange our otherwise *perfect* observations, we may try to obtain some estimate of its amount. If we were to take the errors as indicating the intensity of the influence, the sum of these errors being zero when the mean is assumed as true, would give zero for the entire influence, hence we must take, with Legendre, the square of the error as the measure of intensity. In this way, the sum of the squares of the deviations from the mean may represent the entire force of the deranging influence, and thence the deranging influence on one observation may be estimated. Following this mode with Santini's latitudes, we find 3″·34 as the probable error; but whether this is to be regarded as the probable error of all, or of one of the observations, is not very clear: indeed the whole doctrine is hypothetical. If we grant the soundness of the method of minimum squares, it is easy to show that the probable or possible error of the result is about three-tenths of the ultimate division of the apparatus.

The following Gentleman was elected an Ordinary Fellow:—

Dr WRIGHT, F.G.S., of Cheltenham.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1855–56. No. 46.

Seventy-Third Session.

Monday, 26th November 1855.

Dr CHRISTISON, Vice-President, in the Chair.

The following Council were elected:—

President.

Sir T. MAKDOUGALL BRISBANE, Bt., G.C.B., G.C.H.

Vice-Presidents.

Sir D. Brewster, K.H.
Very Rev. Principal Lee.
Right Rev. Bishop Terrot.
Dr Christison.
Dr Alison.
Hon. Lord Murray.

General Secretary,—Professor Forbes.

Secretaries to the Ordinary Meetings,—Dr Gregory, Dr Balfour.

Treasurer,—John Russell, Esq.

Curator of Library and Instruments,—Dr Traill.

Curator of Museum,—James Wilson, Esq.

Counsellors.

Dr George Wilson.
Charles Maclaren, Esq.
Rev. Dr Robert Lee.
Prof. C. Piazzi Smyth.
Hon. B. F. Primrose.
Sir William Gibson-Craig, Bart.
Colonel Madden.
James Cunningham, Esq.
Dr Greville.
A. Keith Johnston, Esq.
Dr Maclagan.
William Swan, Esq.

Monday, 3d December 1855.

RIGHT REV. BISHOP TERROT in the Chair.

The following Communications were read:—

1. On the Occurrences of the Plague in Scotland during the Sixteenth and Seventeenth Centuries. By Robert Chambers, Esq.

In this paper the author adduced, from contemporary chroniclers and diarists, all the visits of the Pest or Plague which occurred in Scotland after 1560; namely, in the years 1568, 1574, 1585, 1587, 1597, 1607, 1622, and 1645. He cited, from the same sources of information, the notable instances of scarcity and famine; namely, 1563, 1568, 1574, 1578, 1587, 1596, 1598, 1612, 1622, 1642–3. It thus appeared, that while there were several instances of famine not followed by the Pest, there was scarcely one instance of the Pest which was not immediately preceded by a famine. So far the opinion of modern medical writers, that deficient nutrition in the community is one of the predisposing causes of pestilential fevers, may be considered as borne out by facts.

2. On a Problem in Combinations. By Professor Kelland.

This was a problem proposed some years ago by Professor Forbes, when discussing the question of the distribution of the stars. Simple as it is, no prior notice seems to have been taken of it, nor is the author aware that the full solution has yet been given. The problem is this:—"There are n dice, each of which has p faces, p being not less than n; it is required to find the number of arrangements which can be formed with them; 1*st*, "that no two shall show the same face; 2*d*, that no three shall show the same face, and so on." The only part of this problem of which the solution has yet appeared is the first, and the result is $p\,(p-1)\,\ldots\,(p-n+1)$. The author supplies the solution of the remaining portions.

3. Occurrence of Native Iron in Liberia, in Africa. From a Letter of Dr A. A. Hayes, Chemist, Boston, U. S., to Professor H. D. Rogers. Communicated by Dr Gregory.

Dr Hayes states that there is evidence establishing the fact that *pure native* iron exists abundantly in the country back from the central part of the colony of Liberia. Early travellers state that the natives of Africa find iron *ore* so pure, that they heat and hammer it into form. Explorations by the Liberians show that the inhabitants of towns are engaged in manufacturing iron, and an intelligent native has recently shown how it is done. Last year a mass was sent home by a working blacksmith, who cut it with a chisel from a mass of larger size connected with rock. This proved to be native iron, malleable and ductile, yet unequal in its molecular structure. The general arrangement of the particles is unlike that of any artificial iron known, and there are among the iron particles of crystalline and transparent quartz, octahedral crystals of magnetic oxide of iron, and one of the silicates of soda and lime. No traces of carbon exist in connection with it, and no piece of artificial iron has yet reached Dr Hayes which *does not contain carbon*. When analysed by Dr Hayes' mode of electrolysis, it rapidly shows points which are positive to the surrounding portions, and, the action proceeding, the mass becomes honeycombed in texture, while the final chemical result is—

Pure iron, ...	98·40
Quartz, magnetic oxide iron, and silicate lime,	1·60
	100·

The positive points are the crystalline aggregates of the simple minerals, the iron in immediate contact being more open in texture, and always positive in relation to the crystals which are negative.

Professor Rogers supported the view taken by Dr Hayes of the genuineness of the alleged native iron from Africa, by testifying to the experience of that chemist in the technical examination of manufactured iron, and by the statement of his belief, derived from a comparison of many analyses, that the presence of carbon in an iron is the best test of its having been artificially brought to the metallic state. The reputed telluric iron of Canaan in Connecticut, is almost

the only instance in which an alleged native iron has been reported to have been met with, not in loose masses, but in the form of a mineral lode, that of Canaan being stated to be a true vein two inches thick in mica slate. The detection of carbon in this iron proves the specimens to be spurious, and confirms an impression long prevalent among American mineralogists, that the original statement about this vein was founded either in mistake or fraud. An examination of the best authenticated records of native telluric iron tends certainly to reduce the number of the genuine instances, if we accept the carbon test; yet the authorities for the existence of such are too many and too respectable to justify the general incredulity in regard to the presence of native iron on our globe. The statement that this African iron is manufactured in seven villages, is an intimation that it exists in considerable quantity, more than would be compatible with the supposition that it is merely a large mass of meteoric iron. But the fact, particularly significant, against its being native meteoric iron, is the total absence of nickel from its composition, as shown in the full analysis given by Dr Hayes. The absence of carbon indicates it not to be of human fabrication; that of nickel proves it not to be meteoric. Should it really be shown, by further exploration, to exist in quantity, its occurrence on the frontier of a Liberian colony, by presenting another incentive to the settlement of that region by civilized men pursuing the arts of peace, cannot but be regarded as full of good omen for the cause of humanity in Africa.

The following Gentlemen were duly elected Ordinary Fellows:—

James Hay, Esq., Leith. | R. M. Smith, Esq.

The following Donations to the Library were announced:—

Transactions of the Royal Scottish Society of Arts, Vol. IV., Part 3. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. (N.S.) Nos. XLIX, L. 8vo.—*From the Society.*

Transactions of the Architectural Institute of Scotland. Session, 1854–5. 8vo.—*From the Institute.*

Proceedings of the Royal Society, Vol. VII., No. 14. 8vo.—*From the Society.*

Results of Astronomical Observations, made at the Observatory of the University, Durham, from October 1849 to April 1852, under the general direction of the Rev. Temple Chevallier, B.D., F.R.A.S. By R. C. Carrington, Esq., B.A., F.R.A.S. 8vo.—*From the Observatory.*

The Assurance Magazine, and Journal of the Institute of Actuaries. Vol. V., Part 4; Vol. V. Part 1. 8vo.—*From the Institute.*

Journal of the Statistical Society of London. Vol. XVIII., Parts 1, 2, 3. 8vo.—*From the Society.*

The Quarterly Journal of the Geological Society. Vol. II., Parts 1, 2, 3. 8vo.—*From the Society.*

The Journal of the Horticultural Society of London. Vol. IX. Part 4. 8vo.—*From the Society.*—

Monthly Notices of the Royal Astronomical Society. Vol. XIV. 8vo. *From the Society.*

The Journal of the Royal Geographical Society. Vol. XXIV. 8vo. —*From the Society.*

The Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XV., Part 2. 8vo.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. VI. Part 2. 8vo. —*From the Society.*

The Quarterly Journal of the Chemical Society. Vol. VIII., Part 2. 8vo.—*From the Society.*

Notices of the Meetings of the Members of the Royal Institution of Great Britain. Part V.—*From the Institution.*

Proceedings of the Liverpool Literary and Philosophical Society. Session 1854–5. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Nos. 70, 71, 72. 8vo. —*From the Society.*

Abstracts of the Proceedings of the Ashmolean Society. Vols. I. II. III., Part 1. 8vo.—*From the Society.*

Memoirs of the Literary and Philosophical Society of Manchester. 2d Series, Vol. XI., XII. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Prof. Silliman and Dana. Nos. 57, 58, 59. 8vo.—*From the Editors.*

Collection of Charts published at the Hydrographic Office, London. 8vo.—*From the Admiralty.*

Ornithological Synonyms, by the late Hugh Edwin Strickland, M.A. Edited by Mrs H. E. Strickland and Sir W. Jardine, Bart. Vol. I. 8vo.—*From the Editors.*

Astronomical Observations, made at the Radcliffe Observatory. By Manuel J. Johnstone, M.A., 1850, 1851, 1852. 8vo.—*From the Observatory.*

Archæologia, or Miscellaneous Tracts relating to Antiquity, published by the Society of Antiquaries of London. Vol. XXXI. 4to.—*From the Society.*

Proceedings of the Society of Antiquaries of London. Vol. III. No. 52. 8vo.—*From the Society.*

Descriptive and Illustrated Catalogue of the Histological Series contained in the Museum of the Royal College of Surgeons of England. Prepared for the Microscope. Vol. II. 4to.—*From the College.*

Assault of Sevastopol. Two Topographical and Panoramic Sketches, representing the advanced lines of attack, and the Russian defences, in front of Sevastopol, with a description and remarks. The sketches by Capt. M. A. Biddulph, R.A. Fol. 2 copies. *From Capt. Younghusband.*

Transactions of the Zoological Society of London. Vol. 4, Parts 2, 3. 4to.—*From the Society.*

The Origin and Progress of the Mechanical Inventions of James Watt, illustrated by his correspondence with his friends, and specification of his patents. By James Patrick Muirhead, Esq., M.A., 3 vols. 4to.—*From the Author.*

Researches on Colour Blindness, by George Wilson, M.D., 8vo.—*From the Author.*

Magnetical and Meteorological Observations made at the Hon. East India Company's Observatory, Bombay, in the year 1851. 4to. —*From the Hon. East India Company.*

Astronomical and Magnetical, and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1853. 4to. —*From the Observatory.*

Memoirs of the Royal Astronomical Society. Vol. XXIII., 4to.—*From the Society.*

Abstracts from the Meteorological Observations taken at the Stations of the Royal Engineers in the year 1853–4. Edited by Lieut. Col. H. James, R.E. 4to.—*From the Editor.*

Papers read at the Royal Institute of British Architects. Session 1854–5. 4to.—*From the Institute.*

Memoir of Robert Troup Paine. By his Parents. 4to.

Materia Medica and Therapeutics. By Martyn Paine, M.D. 12mo.

The Institutes of Medicine. By Martyn Paine, M.D. 8vo.

Medical and Physiological Commentaries. By Martyn Paine, M.D. 3 Vols. 8vo.

A Discourse on the Soul and Instinct. By Martyn Paine, M.D. 18mo.

Reports and State Documents published by the Senate of Washington.—*From the Senate of Washington.*

Documents relating to the Colonial History of the State of New York. Vols. III. and IV. 4to.—*From the State of New York.*

Smithsonian Contributions to Knowledge. Vol. VII. 4to.

Smithsonian Report. On the Construction of Catalogues of Libraries, and a General Catalogue. 8vo.

Eighth Annual Report of the Board of Regents of the Smithsonian Institution.—*From the Institution.*

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tome XXI., 2me Partie. Tome XXII. 1re Partie. 8vo.—*From the Academy.*

Essai d'une Géographie Physique de la Belgique. Par J. C. Houzean, 8vo.—*From the Author.*

Mémoires Couronnés et mémoires des savants étrangers, publiées par l'Académie Royale de Belgique. Tome VI., 2me Partie. 8vo. —*From the Academy.*

Nachrichten von der Georg-Augusts-Universität und der Königl. Gesellschaft der Wissenschaften zu Göttingen. 1854. Nos. 1–17. 12mo.—*From the Society.*

Annalen der Königlichen Sternwarte bei München. VII. Band. 8vo.

Jahresbericht der Münchener Sternwarte für. 1854. 8vo.—*From the Observatory.*

Monatsbericht der Königl. Preus, Akademie der Wissenschaften zu Berlin, August, December. 1854. 8vo.—*From the Academy.*

Abhandlungen der Mathematisch-physikalischen Classe der Koeni-

glich Bayerischen Akademie der Wissenschaften. VII. Bd., 2 Abtheil. 4to.

Abhandlungen der Historischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. VI. Bd., 2 Abtheil. 4to.—*From the Academy.*

Preisschriften gekrönt und herausgegeben von der Fürstlich Jablonowskischen Gesellschaft zu Leipzig. No. 5. 8vo.—*From the Society.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vol. 24, Pars 2. 4to.—*From the Academy.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd. VIII.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd. XIV. and Bd. XV. Heft 1 and 2. 8vo.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Philosophische historische Classe. Bd. XIV. and Bd. XV. Heft 1. 8vo.

Almanach der Kaiserlichen Akademie der Wissenschaften. 1855. 12mo.—*From the Academy.*

Monday, 17th December 1855.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. Geological Notes on Banffshire. By R. Chambers, Esq., F.R.S.E., &c.

The author described the succession of pleistocene beds at Gamrie, on the coast of Banffshire, as follows (ascending order):—1, boulder clay; 2, a thick bed of sand; 3, a thin bed of brick clay; 4, a thick bed of sand; 5, a thick bed of brick clay; 6, a bed of sand, containing shells of arctic character entire; 7, a moderately thick bed of pure clay; 8, a thick bed of sand; 9, a thin bed of ferruginous gravel (which Mr Chambers regards as the equivalent of the upper till, or coarse gravel, of other geologists); 10, a thick bed of soft blue clay; 11, a thick mass of sand rising to the top of an eminence on which is a vitrified fort. Owing to the great scale on which the formation is presented, and the clearness of the section exposed towards the sea, this is an unusually favourable situation for studying the

Scottish pleistocenes. The shells are the well known *Astarte arctica*, *Natica clausa*, *Tellina proxima*, *&c*.

At Stracheres, on Kineddart Water, six miles inland, the same shells are found in the boulder clay, in a broken state; and opposite Kineddart Castle near by, they are found entire in a sand-bed about thirty feet above the rock, and overlaid with the same ferruginous gravel.

The noted clay bed, containing boulders with lias fossils, at Black-pots, near Banff, Mr Chambers considers as one of the brick clay beds.

At this latter situation the author found a large terrace or ancient sea margin at 64 or 65 feet above the present sea level, and corresponding in elevation to one seen in various other parts of the island. He traced an alluvial terrace of very conspicuous appearance, at about 167 feet above the sea, along both sides of the Deveran River and the minor vale of Turreff, the town of Turreff being seated on it. Another, somewhat higher, is equally prominent in the Kineddart valley.

In the Deveran valley, opposite to Eden Castle, Mr Chambers discovered what he regards as a fine example of an ancient moraine. It commences at the border of a tributary rivulet at Auchinbeddie, and curves for a mile upwards along the hill side, forming an irregular ridge of detrital matter about thirty feet high: the other wing of the same moraine is traceable on the other side of the rill. The little valley of the tributary stream has been the bed of the glacier by which this moraine was formed. On the surface, at short intervals, are flat indentations, surfaced with alluvial matter, and corresponding in level with the two terraces; so that they may be assumed as having been formed by the sea, when it was at the corresponding relative levels.

The author connected this fact of a submergence posterior to the period of local glaciers, with the fact, which he had ascertained in Arran, that that period again was subsequent to a former submergence, during which the noted terrace of erosion round the west coast of Scotland (twenty-five feet above the present sea level) was formed; and, seeing it thus proved that the period of local glaciers was one of elevation, inferred that the cause of the lower temperature of that era was simply our mountain valleys being raised within the region of the snow line.

2. On the Physical Geography of the Old Red Sandstone Sea of the Central District of Scotland. By Henry Clifton Sorby, F.G.S. Communicated by Professor Balfour.

The author endeavours to show that in the Old Red Sandstone period there extended across Scotland a branch of the sea or strait, whose northern shore was somewhere in the line of the mica schist rocks which extend from Aberdeen to the mouth of the Clyde, and its southern in the direction of the Greywacke rocks that run across from St Abb's Head to Wigtonshire. In this, at the earlier part of the period, there were considerable tidal currents; but when the upper beds were deposited, they were more or less completely absent, and there were present such as were chiefly due to the action of the wind.

He shows that there is a most intimate connection between the physical geography of a sea and the currents present in it, and that even their directions and characters can be ascertained from the structures produced in the deposits formed under their influence; therefore, the physical geography of our ancient seas may be inferred within certain limits.

He applies these general principles to the facts seen in the Old Red Sandstone of Scotland, and endeavours to show that the appearances presented indicate the effects of tidal oscillations.

The Council announced that it had awarded the Keith Prize for the Biennial Period ending April 1855, to Dr Thomas Anderson for his Papers on the Crystalline Constituents of Opium, and on the Products of the Destructive Distillation of Animal Substances, both printed in the *Transactions*.

The following Donations to the Library were announced:—

Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, &c. Herausg. von Liebig und Kopp. 1854. 8vo.—*From the Editors.*

Die Fortschritte der Physik in den Jahren, 1850, 1851, 1852. Dargestellt von der Physikalischen Gesellschaft zu Berlin. 8vo. —*From the Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Bd. XV., Heft. 2 & 3; Bd. XVI Heft. 1. Philosophisch-Historische Classe. 8vo.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd. XV. Heft. 3; Bd. XVI. Heft. 1. 8vo.—*From the Academy.*

Abhandlungen der Philosoph.—Philologischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. Bd. XVII., 2 Abtheil. 4to.

Denkrede auf die Akademiker Dr Thaddäus Liber und Dr Georg Simon Ohm, von Dr Lamont. 4to.

Almanach der Königlich Bayerischen Akademie der Wissenschaften, für das Jahr 1855. 12mo.—*From the Academy.*

Archives du Muséum d'Historie Naturelle-publiées par les professeurs-administrateurs de cet établissement. Tome VII. Liv., 3 & 4; Tome VIII., Liv. 1 & 2. 4to.—*From the Museum.*

Aanteekeningen van het verhandelete in de Sectie Vergaderingen van het Provinciaal Utretsch Genootschop van Kunsten en Wetenschappen. 1845–54. 8vo.

Verhandeling over de verdiensten van Gijsberet Karel van Hogendorp, als Stautshuishoudkundige ten aanzien van Nederlands, door M. O. Van Rees. 8vo.

Description de l'Observatoire météorologique et magnétique à Utrecht. Par P. W. C. Krecke. 8vo.—*From the Academy.*

Astronomical and Meteorological Observations made at the Radcliffe Observatory in the year 1853, under the superintendence of Manuel J. Johnson. M.A. Vol. XIV. 8vo.—*By the Trustees.*

Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo V. 4to.—*From the Academy.*

Journal of the Asiatic Society of Bengal. Nos. 3 & 4. 1855. 8vo. —*From the Society.*

Almanaque Nautico para el ano 1856, calculado de orden de J. M. en el Observatoro de Marina de la Ciudad de San Fernando. 8vo.—*From the Observatory.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1854. Nos. 2, 3, and 4. 8vo.—*From the Institute.*

Bulletin de la Société de Géographie. 4ieme Serie. Tom. 8 and 9. 8vo.—*From the Society.*

Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. 1854–5. 8vo.—*From the Society.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1853. Nos. 3 and 4. 1854. No. 1. 8vo.—*From the Society.*

Medico-Chirurgical Transactions. Published by the Royal Medical and Chirurgical Society of London. Second Series. Vol. XX. 8vo.—*From the Society.*

Journal of the Ethnological Society of London. Vols. I. II. III. 8vo.—*From the Society.*

Transactions of the Pathological Society of London. Vol. VI. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVIII. Part 4. 8vo.—*From the Society.*

Observations Météorologiques faites à Nijné Tagulsk (Monts Oural). Governement de Perm. 1850–51–52–53. 8vo.

Collection of Naval Charts from the *Depôt General de la Marine.* 8vo.—*From the French Government.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. 2de Deel. 4to.

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. 2de Deel. 3de Stuk. 3de Deel. 1ste & 2de Stuk. 8vo.

Catalogus der Boekeri van de Koninklijke Akademie van Wetenschappen, gevestigd te Amsterdam, 1ste Afler. 8vo.—*From the Academy.*

Analytisch-geometrische Untersuchungen über Allgemeine Verwandtschafts-Verhältnisse von Coordinaten-Systemen. Von J. G. H. Swellengoebel. 4to.—*From the Author.*

Kongl. Vetenskaps Akademiens Handlingar. 1853. 8vo.

Kongl. Vetenskaps Akademiens Ofversigt. 1854. 8vo.

Kongl. Vetenskaps Akademiens Arsberättelser af Wikström 8vo.

Kongl. Vetenskaps Akademiens Arsberättelser af Boheman. 8vo. —*From the Academy.*

Memorie della Reale Accademia delle Scienze di Torino. Tome XIV. 4to.—*From the Academy.*

Mémoires de l'Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Tomes XXVIII. XXIX. 4to.—*From the Academy.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch Naturwissenschaftliche Classe. Bd 9. 4to.

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Philosophisch Historische Classe. Bd 6. 4to.

Jahrbüchr der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Von Karl Kreil. III. Bd. 1851. 4to.—*From the Academy.*

Bulletin der Königl. Akademie der Wissenschaften (München). Nos. 1–52. 4to.—*From the Academy.*

Compte rendu Annuel, par le Directeur de l'Observatoire Physique Central, A. T. Kupffer. 1853. 4to.—*From the Editor.*

Della vita e delle opere di Guido Bonatti, Astrologo ed Astronomo del secolo decimoterzo notizie raccolte da B. Boncompagni. 8vo.—*From the Author.*

Annuaire de l'Académie Royale des Sciences, &c. de Belgique. 1854–55. 12mo.

Académie Royale de Belgique, Bibliographie Académique. 1854. 12mo.

Annuaire de l'Observatoire Royal de Bruxelles. 1854–55. 12mo.

Almanach Seculaire de l'Observatoire R. de Bruxelles. 1854. 12mo.—*From the Academy.*

Monday, 7th January 1856.

Dr CHRISTISON, Vice-President, in the Chair.

Professor Christison, in delivering the Keith Medal to Dr Anderson of Glasgow, made the following remarks:—

Dr Anderson—It is a peculiar pleasure to me to be the organ of the Society this evening for presenting to you this token of the approbation of this Society and its Council.

As there must be many now present who are unacquainted with the origin, conditions, and mode of adjudication of the Keith Prize, I hope that others will bear with me for a moment till I state these very briefly. The prize was founded by the late Sir Alexander Keith of Dunottar and Ravelston, to be given to the author of the best paper read in this Society during each successive biennial period. The Council were appointed to administer the fund, and to adjudicate the prize. The adjudication is determined by advice of a committee of the Council specially nominated for the purpose. Having been a member of the Council almost since the foundation of the prize, and repeatedly a member of the Prize Committee, I can testify to the exceeding care, and anxiety, and impartial disposition of the Com-

mittee and Council on all occasions. The best proof, perhaps, to this effect is that their award, so far as I am aware, has never been subjected to challenge in the public prints; nor have I ever heard it criticised even in private society. A still more satisfactory proof, as some may think, is the eminence of the men to whom the prize has hitherto been awarded. The first was awarded in 1828 to Sir David Brewster; the next to Mr Graham, now Master of the Mint; Sir David Brewster then received it a second time; our much esteemed secretary, Professor Forbes, has been twice similarly honoured; another was awarded to Mr Scott Russell for his researches on the "Wave-theory;" another to Mr Shaw for his experiments on the development and growth of the salmon, which have yielded since most important practical results; another to our revered president—whose duty I am now, in his unavoidable absence, inadequately discharging—for his laborious and munificent "Magnetical Observations;" and the last awards were to Professor Kelland and Mr Macquorn Rankine for elaborate and important mathematical investigations. I do not state these facts for the sake of taking any credit to the Council for the discharge of a duty, but in order that Dr Anderson himself, as well as his fellow-members of this Society, may duly appreciate that gentleman's honourable exertions, which have yielded results entitling him to be similarly rewarded on the present occasion, and to be associated with such predecessors.

Among the previous awards I may be permitted, I hope, to advert to certain circumstances connected with the last adjudication of the Keith Prize for a chemical paper—namely, to Mr Graham in 1834, for his admirable researches on the "Law of the Diffusion of Gases." For it was this paper, and in some measure the reading of it in this Society, which laid the foundation of his fortunes. The paper excited intense interest at the time in the Society, both among scientific members and others; and his name in consequence became well known to many. It may not perhaps be known to Mr Graham himself, but when he was a candidate for the chair of chemistry in University College, London, reference was made by the College authorities to several Fellows of this Society; and I have reason to know that the unanimous opinion, greatly deduced from his paper, and expressed in reply to these inquiries, had much to do with his appointment to succeed the late

Dr Turner. The present is only the second occasion, and after an interval of twenty-one years, that the prize has been assigned for a chemical paper. I do not know what the chemists have been about in the interval, but it is to be hoped that they may now be stimulated by Dr Anderson's successful example.

It is usual for one in my present position to give some account of the researches for which the prize has been adjudicated by the Council. This, however, I will, I daresay, be excused for not attempting. The papers—for they are two in number—are on "the Products of the Destructive Distillation of Organic Substances," and on "the Crystalline Bodies obtained from Opium." I find it impossible to give an adequate analysis of these papers which would not be too tedious for delivery now. In fact, they are scarcely capable of abbreviation, and must be perused in their entire state, in order to be followed. In the course of his experiments on both subjects, Dr Anderson has examined a great many bodies previously known, and discovered others of great scientific interest, and ascertained the composition of all, notwithstanding that they are all of great complexity. I must be satisfied with merely informing that great proportion of his fellow-members who may find it difficult to follow his elaborate researches, that they belong to the most recondite and difficult department of chemical analysis. It has happened that, with only one or two exceptions, the Keith Prize has been assigned to authors who have not only written each a paper of high merit, but have likewise contributed many others of value to our proceedings. So it is in the present instance. Dr Anderson, when a very young chemist, communicated to the Royal Society his first paper in 1842, only one year after his graduation, on the analysis of two zeolitic minerals; and we have been favoured by him with many other excellent researches since. But his last are the most elaborate and productive.

I have said that both topics of these papers belong to the most recondite branch of chemical analysis. There are not wanting people who regard such difficult inquiries slightingly, because they do not lead to any apparent practical results of importance. You will hear such recondite researches characterized as *difficiles nugæ*, and very lightly esteemed accordingly. But in these days no one who respects himself will fall into so gross an error. Dr Anderson's researches are all concerned with great che-

mical laws, and bodies developed in consequence of the existence of them. These laws exist, because they were established by Providence; and we may depend upon it that they were not established without a purpose, and that a beneficent one. Permit me to give a proof of this. The great discovery of the existence of the vegetable alkaloids, commenced nearly forty years ago, belonged in its day to one of the most abstruse departments of chemical analysis. There are others besides myself in this room who may remember that for some years afterwards the successive discovery of these bodies was lightly spoken of as *difficiles nugæ*—or laborious trifling. But a different view came to be taken of such inquiries, when it appeared that all the vegetable alkaloids concentrate in themselves the poisonous and medicinal properties of the vegetables which yield them. Among the truly practical and beneficent results that have ensued, let me mention one great fact—namely, that with one of these alkaloids, intermittent fever, one of the most common diseases of hot and even of some temperate climates, may be cured with almost as great certainty as we can appease hunger with bread or with meat. I shall detain you by mentioning only one other illustration—the newest of all. In the course of a very elaborate inquiry in a far-removed corner of organic chemistry, a body was discovered which is known to chemists by the scientific name of terchloride of formyl. This was in 1832. For many years it belonged to the *difficiles nugæ;* no one even saw it, except occasionally some chemist more curious than his fellows in general. I venture to say that many here present do not know the name, and may think it requires the alchemy of Dr Anderson, and such as he, to understand it. At last, after the lapse of fifteen years, this was discovered to be the powerful agent which has since been more familiarly known by its oldest name chloroform, one of the kindest gifts of Providence to man. Let all beware, then, of speaking lightly of the elaborate and apparently unproductive chemical researches of the present day. Who knows but that among the curious new bodies discovered by Dr Anderson, there may yet be found another gift not inferior to that of chloroform, or that of quina?

I set out with observing, Dr Anderson, that it was a peculiar pleasure to me to be honoured with the duty of presenting this prize. It would be a great pleasure in any circumstances, but it is peculiarly so when I have to convey this impartial mark of our

Society's respect to one who, once my pupil, and afterwards my friend, is now also my professorial brother. It is well known to your early friends that it would have been easy for you, under the auspices of your late father, to have soon attained a competence and independence as a medical practitioner; but you preferred the more thorny path of science. I happen to know that your choice gave some uneasiness and anxiety to your parent, when he reflected how few,—alas! for the scientific welfare of this country,—how very few prizes in chemical science are held out to its votaries in Britain. But he was reassured by the assurance of his friends that the spark so clearly visible would soon be blown into a flame; and, accordingly, he lived long enough to see you received by universal consent among the chemists of Europe, and rewarded by the second—if, indeed, it be only the second—chemical office, in point of honour in Scotland.

I must not conclude without mentioning that the value of the Keith Prize is not be measured by this medal merely. Apart from the honour, the prize varies in value from £50 to £65, and the latter sum is its amount on the present occasion. It is, therefore, in all respects, an object well worthy of competition among scientific men.

The following Communications were then read:—

1. Geometry, a science purely experimental. By Edward Sang.

After remarking that the perfect strictness of the demonstrations in Geometry is generally admitted, the author of the paper cited the almost universal belief in the soundness of Euclid's reasoning as a notable example of wide-spread credulity. He then enunciated the proposition that our knowledge of the truths of geometry is altogether derived from experience.

Taking the first of Euclid's problems, "To construct an equilateral trigon," he showed that the facts that the circles intersect at all, and that they have only one intersection on each side of the base, are taken for granted, and he contrasted the looseness of this procedure with the hypercritical precision of the following problem "to cut from the greater of two lines a part equal to the less."

Proceeding from the propositions to the axioms, he denied that the human mind possesses the innate power of perceiving a general truth: and asserted that, without a knowledge of all the cases to which a statement may be made to apply, we are not safe in enunciating it; thus, adopting the definition of equality as implied in Euclid's eighth axiom, the proposition "if equals be added to equals the sums are equal," is not true; the sums may be equal or they may be equivalent. And, as an instance of the ease with which we may be led to admit the truth of a specially worded proposition, he cited this one:—"perfect equality implies equality in size, in shape, in weight, in colour, and in every respect in which we can compare them, so that of two perfectly equal bodies, the one could not be distinguished from the other; perfect equality, then, must include every inferior degree of resemblance." Such is an axiom to which most people would assent as self-evident—yet it is not true.

Even the axiom "things equal to the same thing are equal to each other," is not to be admitted without examining the particular kind of equality implied; for though bodies similar to the same body be similar to each other, and those equivalent to the same equivalent to each other, solids symmetric to the same solid are not symmetric to each other.

Passing from the axioms to the definitions, he pointed out the necessity of establishing the possibility of the thing defined: thus if we form such a nomenclature as this; a solid with four trigonal faces is called a tetrahedron, a solid with five trigonal faces is called a pentahedron, one with six trigonal faces a hexahedron, and so on, our definitions would be essentially vicious, since no such pentahedron can exist; and thus we see that our definitions of the tetrahedron and hexahedron are only admissible after examination.

Again it is necessary to take care that the definition of one object be consistent with that of another. Thus, having defined a straight line, we are not at liberty to use the straight line in defining a plane surface until we have made sure that this use is consistent with what has already been predicated. Now the ordinary definition of a plane surface is, that *the straight line joining any two points in it lies wholly on the surface.* This definition, however, implies a very abstruse property of straight lines; namely, that if two straight lines be drawn from one point, and if two points be assumed in each of them, the two straight lines joining alternately the

remote point on the one line with the near point on the other cross each other. Until the truth of this proposition shall have been demonstrated we are not at liberty to define a flat surface. This demonstration can only be obtained by experiment, and, therefore, it was concluded, all our knowledge of geometry being founded on this proposition, is experimental.

2. Notice respecting recent Discoveries on the Adjustment of the Eye to Distinct Vision. By Professor Goodsir.

The question as to the arrangement by means of which the eye is adapted for distinct vision at different distances has for two centuries strongly attracted the attention of physiologists. The numerous hypotheses, and untenable theories which have been advanced on this subject are all, however, more or less unsatisfactory. They are severally based on

1. The mere structure or form of the refractive humours of the eye;
2. A presumed process connected with change in the direction of the axis of vision;
3. The movements of the iris;
4. Change in the position of the retina;
5. Change in the position of the lens;
6. Change of form of the cornea;
7. Change of form of the lens.

This important question has now been definitively determined by the researches of Dr Cramer of Groningen, detailed in a prize treatise submitted to the Dutch Association for the advancement of medical science in 1851; but, which, except in the form of a short abstract at the time, was only published at a later period. In 1853, Helmholtz also announced to the Berlin Academy the same discovery, reached independently, and by a method more complex than that employed by Cramer.

The entire question had been previously simplified by the conclusion to which Volkmann had come, that the eye, when in a passive condition, is adapted for the vision of distant objects, the foci of convergent pencils being then situated in the retina; that when it requires to be adjusted for a near object, an active process of accommodation is set up, which brings the foci forward to the nervous

membrane; and that the return to the passive condition, which again adapts the eye to distant objects, is a passive process, following on the previous effort.

Cramer had therefore only to determine the nature of the active change, by means of which the foci, for a near object, are brought forward to the retina. Now, as Helmholtz had shown, that the adaptation of the eye to distance must depend upon a change of some kind in the refractive condition of the humours of the organ; and as Senff had previously proved that no change takes place in the curvature of the cornea; and as the ingenious theories of Ludwig and Stellwag had in no way removed the difficulties involved in explaining how the lens can be moved forward; there remained only, as a basis for investigation, the hypothesis of a change of form of the lens. This hypothesis, as Volkmann had stated, could only be objected to as insufficient; but not as involving any contradiction of fact; and might be verified by more careful and extended observation.

The question, therefore, which Cramer had to determine, was this—is the form of the lens changed in the adaptation of the eye to near objects?

Cramer was indebted to Donders for the fundamental idea on which he proceeded in the solution of this question. Donders had previously entered on the investigation, but had failed in his observations. He is entitled, however, to the credit of having suggested the employment of the experiment of Purkinje in this inquiry; and of having subsequently elucidated its successful results.

Cramer has discovered that in the adjustment of the eye for a near object, there takes place a change in the form of the lens, consisting of an increase in the curvature of its anterior surface, produced by the iris and ciliary muscle, but without alteration in the position of the lens itself; while the return to its original form for the vision of a distant object is the effect of its own elasticity, which in proportion to the pressure applied, had co-operated in producing the increase of its anterior convexity. He ascertained the occurrence of this alteration of form by watching, through an arrangement of his own contrivance magnifying from 10 to 20 diameters, the change which takes place in the image of the flame of a candle reflected from the anterior surface of the lens during the adjustment of the eye to a near object. The eye having been adjusted to a distant object, and the erect image from the surface of the cornea having been brought nearly to the

margin of the iris in the pupil, the erect image from the front of the lens will be observed deeper and less distinct, a little beyond the centre of the pupil, and the small distinct inverted image from the back of the lens will be close to the opposite margin of the iris. The eye being now adjusted to a near object, the deep erect image advances, diminishes, becomes more distinct, and moves across the centre of the pupil to the immediate neighbourhood of the corneal image.

This change in the relative position of the three images was correctly considered by Cramer as a distinct evidence of an increase in the curvature of the anterior surface of the lens. It would appear, however, that he was not entitled to conclude, as he did, from the immobility of the inverted image, that no change occurs in the posterior curvature of the lens. Donders, in reference to this has asserted, that the immobility of the inverted image affords satisfactory evidence that a change does actually occur in the curvature of the posterior surface of the lens; and Stellwag has demonstrated that a change of this kind must necessarily take place. That there is a contemporaneous increase in the curvature of both surfaces of the lens must be admitted from the consideration that if such a change did not occur in the posterior surface, the increased curvature of the anterior would necessarily produce a change in the position of the inverted images; which is not the case. The optical effect of the increase of anterior curvature masks the slight movement of the inverted image.

The alteration in the curvature of the posterior surface is, however, so slight, that we may safely assume that the essential alteration takes place in the anterior surface.

Helmholtz has proved that the anterior curvature of the lens is increased during adjustment of the eye to near objects, by measuring accurately the distance between the images of the flames of two candles reflected from that surface, in the active and passive conditions of accommodation. According to his calculations the radius of curvature of the anterior surface is, for distant vision, from 10 to 11 millimetres; for near vision about 5 millimetres.

A change in the form of the lens having thus been ascertained to be the mode of adjustment of the eye to distances; the next point to be determined is the mechanism by which the change of form is effected.

It may be stated generally, that although the structures which act

upon the lens have been ascertained, the details and arrangements of the process itself still require elucidation.

Cramer removed the eye of a seal immediately after the death of the animal, and exposed a portion of the surface of the vitreous body at the back of the organ. He then introduced the electrodes of an electro-magnetic rotation apparatus into the opposite attached margins of the iris. The flame of a candle at the distance of 35 centimeters from the cornea was distinctly observed on the vitreous surface, with a microscope magnifying 80 diameters. At each passage of the electrical current through the organ, the pupil contracted, the image of the flame became broader, less distinct, and less definitely outlined. This effect was visible to the naked eye, and indicated the probability of the form of the lens being altered by the contraction of the muscular structures in the interior of the eye. Cramer ascertained that the iris is at least the principal agent in producing the change ; for when a cataract needle was introduced so as to divide the iris, and produce a complete coloboma, the focus was no longer affected by the electrical current. Cramer also removed the cornea, annular ligament, and iris, after which the electrical current produced no change in the adjustment; although the ciliary processes were observed to be put upon the stretch. The lens was also shown by numerous experiments to be incapable of changing its own form. It is not muscular ; for when the recent lens was removed from the eye, and the flame of a candle brought to a focus through it, on a piece of oiled paper, the electrical current produced no change in the adjustment.

Cramer concludes, in this department of his subject, that the iris and ciliary muscle alter the form of the lens. The ciliary muscle contracting pulls the ciliary processes forward, and so prevents the lens from receding under the pressure of the iris. The latter produces the change in the anterior curvature, by a primary contraction of its circular fibres; followed up by contraction of its radiating fibres, which, from being curved forwards, become straight, and thus pressing on the marginal portion of the anterior surface of the lens, force the central portion forwards. Cramer's explanation of the action of the iris on the lens is based on Stellwag's recent assertion, that the posterior chamber has no existence, but that the iris rests immediately on the front of the lens, the ciliary processes, and the zonule of Zinn, so that it projects like a dome into the ante-

rior chamber. The pressure is thus communicated by the iris to the lens through the medium of the ciliary processes, zonule of Zinn, and contents of the canal of Petit, the lens being supported and kept forward by cotemporaneous contraction of the ciliary muscle. Donders is inclined to believe that a very thin layer of fluid is interposed between the iris and the structures behind it; but practically Cramer's opinion appears to be correct.

Hueck, in attempting to explain ocular adjustment by the movement of the lens by the iris, had stated that when viewed in profile, the iris is seen to project into the anterior chamber during vision of a near object. Volkmann denied this; but the fact is undoubted; and Helmholtz has ascertained that the protrusion is about $\frac{1}{3}$ millimetre.

Ruete has objected to Cramer's conclusion as to the agency of the iris in altering the form of the lens, on the ground that in cases of congenital deficiency of the iris the power of adjustment is not deficient. In such instances some compensating arrangement must exist.

Senile Presbyopia mainly depends, according to Cramer, on the diminished muscular contractility of the iris and ciliary muscle. Myopia, again, on diminution of the elasticity of the capsule of the lens, which disables the lens from regaining its normal form after each act of adjustment. He denies that the curvature of the cornea is increased in myopia, and states that the apparent increase is due to the continued increased protrusion of the iris into the anterior chamber.

The following Gentleman was duly elected an Ordinary Fellow:—

David Bryce, Esq., Architect.

Monday, 21*st January* 1856.

Colonel MADDEN, Councillor, in the Chair.

The following Communications were read:—

1. Memoir of Rear-Admiral Sir John Franklin. By Sir John Richardson, C.B. Communicated by Professor Balfour.

2. On the Geological Relations of the Secondary and Primary Rocks of the Chain of Mont Blanc. By Professor Forbes.

This paper* is intended to meet the objections taken by Mr D. Sharpe, in a paper published in the *Quarterly Journal of the Geological Society for February* 1855, to the views of the present writer, and those of several eminent geologists, on the structure of the chain of Mont Blanc.

De Saussure first described the singular superposition of gneiss to limestone which occurs on the south-east side of the valley of Chamouni, a testimony the more clear from its obvious opposition to the Wernerian views of the period.

M. Necker, grandson of De Saussure, in a remarkable paper on the granite of Valorsine, published in 1828, presents a section of the south-east slopes of the valley of Chamouni, which exhibits the limestone dipping under the gneiss, the beds of which gradually become steeper as we approach the centre of the chain. The facts were still more emphatically stated by the same author in a work on the Geology of the Alps, published thirteen years later.

In 1842, Professor Forbes paid particular attention to the structure of *both* sides of the chain of Mont Blanc; and pointed out the precise analogy of the superposition of gneiss to limestone on the Italian, to that on the Swiss side of the mountain. He indicated very distinctly two localities, one on each side of the Alps, where the superposition might be distinctly seen and traced for some distance.

Mr Sharpe, in the paper referred to, having treated the descriptions of De Saussure and of M. Necker as vague or contradictory, the present writer defends them. And he repels Mr Sharpe's objection to his own conclusions as not based on sufficiently definite indications of the localities, by citing the passages from his *Travels in the Alps*, where he has specified them, and by showing that other geologists have satisfactorily verified his observations.

He next quotes the testimony of M. Favre of Geneva, and of M. Studer of Berne, as having from personal observation of the closest kind, been led to conclusions identical with his own.

* It will be printed at length in the *Edinburgh New Philosophical Journal for April* 1856.

Finally, he gives examples from the writings of M. Elie de Beaumont of similar anomalous superpositions in the Alps of Dauphiné, and in the writings of M. Hugi and M. Studer, of others in the Canton of Berne, which would leave the fact in question still to be accounted for, even if all geologists from the time of De Saussure had been in error as to the particular constitution of the chain of Mont Blanc.

The paper was illustrated by sections showing the views of successive geologists.

The following Gentlemen were duly elected Ordinary Fellows:—

W. Mitchell Ellis, Esq.
Dr G. J. Allman, Prof. Nat. History, Edinburgh.

Monday, 4th February 1856.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read:—

1. On the Turkish Weights and Measures. By Edward Sang, Esq.

In this paper a short account was given of the comparison of the oka with the imperial grain weight, and of the arsheen with the inch.

The oka was stated to be 19,807 grains, so that 18 cantar of 44 oka each make one ton one pound.

The length of the arsheen was determined by comparison with the ebony standard of Sultan Selim.

The extreme length, as obtained by contact, was 29·890 inches, but the ends had evidently been tampered with; on that account the divisions of the rod were referred to; these gave results varying from 29·944 to 29·949, and therefore the mean, 29,946 inches, may be taken as the true length of the Turkish arsheen.

2. Observations on *Polyommatus Artaxerxes*, the Scotch Argus. By Dr W. H. Lowe.

Polyommatus Artaxerxes, or the Scotch Argus, is an insect not only of great local interest, but has attracted, and continues to

attract, the notice of entomologists all over the world. Among the English, and still more among the foreign students, who annually throng our University, there are always a considerable number who arrive in Edinburgh anxious to see "the rare butterfly from Arthur's Seat," or who are commissioned by entomological friends to obtain it. Besides, there are the still more destructive emissaries from the London and provincial dealers in insects, who infest the hill during the season in which it is found. But although the situation in which this insect is principally taken is extremely circumscribed, I am not aware that its numbers are materially diminished by this continuous drain upon them. The new road now in contemplation beneath "Samson's Ribs," and through the village of Duddingston, will, I fear, go far to exterminate it, as it will pass, I believe, through the exact spot upon which it is found, and to which it is in a singular degree limited.

The first published account we have of this insect is by Fabricius, in his "*Systema Entomologiæ,*" 1793, under the name "*Lycæna Artaxerxes,*" in which he states its habitat to be "Anglia," but without any special reference to Scotland. He does this on the authority of Mr Jones of Chelsea, in whose cabinet a specimen then existed; but it would appear that Fabricius himself never saw the insect, as it was at that time a frequent custom to insert in entomological cabinets a painted piece of card, to supply the place of an insect then believed to be too rare to afford much probability of its being obtained. I may here mention, that naturally feeling some interest to know who this Mr Jones of Chelsea (so often quoted by authors) was, I applied to Mr James Wilson of Woodville, who most obligingly wrote to Mr Adam White, of the British Museum, and through whom we find that Mr Jones had an excellent collection of native insects, and also a number of illustrations, coloured by himself, which are still in existence; but from the higher degree of excellence now attained in such delineations, of course greatly diminished in pecuniary value, however interesting they may have been at the time alluded to. It was no doubt one of these illustrations which Fabricius availed himself of in his *Systema Entomologiæ.* We find this insect next mentioned as *Papilio Artaxerxes* by Lewen (1795), a fellow of the Linnean Society, who, like Fabricius, refers to Mr Jones' specimen, but adds, that it was taken in Scotland. In the *Natural History of Insects*, by Donovan, in 1813, we have

the first full account of this insect; and his description is so animated and enthusiastic, that the naturalists of the Society, if not the other fellows, will excuse my making one quotation from him:—"To the great astonishment of our English collectors of natural history," he says, "*Papilio Artaxerxes*, an insect heretofore of the highest possible rarity, has been lately found in no very inconsiderable plenty in Britain. For this interesting discovery we are indebted to the fortunate researches of our young and very worthy friend, W. E. Leach, Esq., who met with it common on Arthur's Seat, near Edinburgh, and also on the Pentland Hills." It will not be uninteresting to the fellows of this Society to know that Mr James Wilson was with Dr Leach on this occasion, and joined him in his entomological researches at that time. As I have entered so far into the history of this insect, I must now in fairness state, that the same authority (Donovan) mentions the existence of a specimen in the "extensive and valuable" cabinet of Mr Macleay, taken in Scotland, previous to Dr Leach's discovery. It is the same Mr Macleay whose name is associated with another interesting, but much more widely distributed insect, the *Erebus Blandina*, or Arran Argus. Donovan concludes with the remark—"As these insects fly in the day-time, there can be little doubt they may be sought for by the collectors with success on the hilly spot called Arthur's Seat, near Edinburgh."

Polyommatus Artaxerxes, thus established as a well-known British insect, appears successively in the works of Mr Stephens, 1828; Rennie (*Conspectus*), 1831; Duncan, 1837; Wood (illustrated catalogue), 1839; Westwood, 1841; and Captain Brown, 1843; but I do not think there is in these works any important addition to the information I have thus thrown together.

Having endeavoured to trace rapidly, and in a manner as little tedious as possible, the history of *P. Artaxerxes*, I may remark, that great as is the interest this insect has excited among naturalists, its habits, and especially its transformations, were until recently entirely unknown. Mr R. Logan, who resides almost on the spot on which it abounds, endeavoured some years ago, I believe, to obtain its larvæ by inclosing a number of the perfect butterflies beneath a glass frame in his garden, in the hopes that the eggs might be deposited; but as at that time it was generally believed to feed on the *Ulex europæus*, amidst which it may be seen to flit, the eggs, if deposited at all,

naturally perished for want of their proper nidus; and this laudable experiment of course failed. The same accurate and patient observer, however, subsequently arrived at the belief that the insect preferred the *Helianthemum vulgare*, which grows luxuriantly on the south side of the hill, remarking, that while the *Ulex europæus* abounded all over the hill, the butterfly did not, but was confined to the south, and only where the *Helianthemum* grew, frequently indeed in conjunction with the *Ulex*. This inference has since proved correct. So lately as 1851, Mr Logan, in an article in the *Naturalist* for March in that year, after describing the *P. Artaxerxes* as they may be seen gaily flitting over the banks of Arthur's Seat in the sunshine, or resting on the tall culms of grass and other plants while quiescent, remarks: "Strange to tell, no one knows anything of their history; where they lay their eggs, or what the larva feeds on, and where the inactive chrysalid passes the long, cold months of winter, are all in mystery;" and adds, "the discovery of the caterpillar and chrysalis is a point much to be desired." Struck with these remarks, published too just before the insect might be expected to make its accustomed annual appearance, I determined to go to Arthur's Seat for the express object of finding this long looked-for chrysalis. I spent several hours diligently examining the stems of different plants, particularly the *Ulex europæus* and the *Helianthemum vulgare;* the latter of which I frequently tore up bodily, and examined piecemeal. I did this in the belief that all the Polyommati attached their chrysalids to the stems of plants, as is indeed the usual habit of this genus, and was ignorant that any of them burrowed in the ground. My time and patience being nearly exhausted, I now began to dig in the loose earth which lies beneath the bushes of furze, the shade of which precludes anything from growing beneath them. Here I was also unsuccessful, but seeing some tufts of *Helianthemum* overhanging some barren patches of earth, I continued my examination there also, and almost immediately found several chrysalids, the appearance of which left me no doubt that they were those of *P. Artaxerxes*. The day was now declining, and I was anxious to show my acquisitions to Mr Logan, to whose house I immediately repaired. That gentleman showed the greatest interest in the discovery, and, like myself, expressed his surprise that one of the genus *Polyommatus* should bury its chrysalis in the ground instead of attaching it to the stem of a plant. He further requested me to place the chrysalids in his keep-

ing, that he might figure them for a work upon which he has long been engaged, and to which this society has become a subscriber. A few days after, I received the said chrysalids from Mr Logan, and he at the same time mentioned that, acting on the information I had given him, he had pursued the search for the chrysalids, and had found them in considerable numbers. Those I had in my own possession emerged from the chrysalis, either that day or the following; and since that time it has, of course, become easy to note the habits of *P. Artaxerxes*, and a beautiful delineation of it in all its stages of development will appear in Mr Logan's book, whenever its appearance shall realize the expectations of his numerous subscribers.

To go further into the description of its transformations at this point would be to trespass on the subsequent but as yet unpublished observations of Mr Logan, and I shall therefore leave it now, to say a few words in conclusion on *Polyommatus Agestis* and *P. Salmacis*, two insects so nearly allied to the one before us that they have been at different times considered to be one species. On looking at the drawings of these three closely allied insects, for which very faithful and beautiful illustrations I am indebted to my friend Mr Dallas, we perceive that *P. Artaxerxes* is readily enough distinguished by the conspicuous white spot in the angle of the upper wing, while *P. Agestis* has a black one in nearly the same position. These markings, though affording in themselves but slight grounds for specific distinction, are nevertheless permanent in their character, and even before we were acquainted with the caterpillars of the respective insects, gave great probability to the opinion that the two were distinct, especially when taken in conjunction with the fact that *P. Artaxerxes* is confined to Scotland and the north of England, and *P. Agestis* as exclusively to the southern counties of England. Still this was matter of opinion, and it is only now that we are enabled by our own observations in Scotland upon *P. Artaxerxes*, and almost at the same time by similar observations by Mr Harding and Mr Stainton in London upon *P. Agestis*, to determine, as I think, finally upon the specific difference of the two insects. The gentlemen I have just named have bred *P. Agestis* from the caterpillar, and find that it feeds upon *Erodium cicutarium*, a plant in natural affinity and every other respect widely removed from *Helianthemum vulgare*. When, therefore, to the slight but permanent differences of its external markings and habitat is added the fact that the caterpillar of the

one feeds upon a plant so different from the food upon which the other is found, that probably the food of the one would poison the other, it appears to me that the specific distinctions between the two insects may be regarded as established.

We have, however, *P. Salmacis* still remaining undetermined, its caterpillar and chrysalis not having as yet been found. The chief distinction to be remarked in its external character is the slight but peculiar areola of white scales which surround the black spot occupying an exactly similar position in the upper wing as in *Agestis*. Although Mr Doubleday regards this insect as a variety of *P. Artaxerxes*, I have always felt and still believe it to be much more closely allied to *P. Agestis*. During last year (1855) I visited Castle-Eden-Dene, the habitat of *P. Salmacis*, and bearing in mind my observations on Arthur's Seat, felt sure I should by digging in similar places under the tufts of *Helianthemum* find the chrysalids. In this I was unsuccessful, although the *Helianthemum* was most abundant. The spot on which *P. Salmacis* is found faces the sea (the German Ocean), and the ground is a stiff wet clay, with dense, coarse herbage, both ill suited for burying its chrysalid, if that be its habit; nor is the *Helianthemum* the *prevailing* plant there. Mr Wailes observes, that he has never found it more inland than a quarter of a mile from the sea; and although the *Helianthemum* is most abundant in the upper part of the Dene, Mr Tristram, the clergyman of the district, and other residents, assured me it was never seen except on the spot I have named, by a high cliff of clay overhanging the sea. This certainly suggests the idea of its being dependent on some littoral plant growing only within a certain range of the salt water. I observed the *Anthrocæra filipendula* and *Procris statices* flying in great numbers together with *P. Salmacis*, and their chrysalids attached to the stems of plants were abundant. I did not at the time know of Mr Harding's observations, and that *P. Agestis* fed upon *Erodium cicutarium*, and, consequently, did not particularly note whether that plant grew there; but having been accustomed to botanical observations all my life, I think I should certainly have noticed it if it had been the prevailing plant,—a thing, moreover, which the stiff clay soil renders improbable. What I did notice was the *Geranium sanguineum* in great quantity (the flowers filled with Ceutorhynchus geranii), a plant not far removed in natural affinity from the one I have just named. Altogether, I feel inclined to predict that *P.*

Salmacis may be found to feed on *Geranium sanguineum*, and to attach its chrysalids to the stems; but this is mere surmise, and until its transformations have been observed, it must still remain, as it now is, an undetermined species.

3. On Solar Light, with a Description of a simple Photometer. By Mungo Ponton, Esq.

The first part of this communication was occupied with a detail of some observations, made in the course of last summer, on the quantity and intensity of Solar light, as compared with familiar sources of artificial flame. The instrument employed for these observations was a simple monochromatic photometer, whose construction was minutely described.

The results obtained were stated to be, that a small surface, illuminated by mean solar light, is 444 times brighter than when it is illuminated by a moderator lamp, and 1560 times brighter than when it is illuminated by a wax candle (short six in the lb.),—the artificial light being in both instances placed at two inches distance from the illuminated surface. It was then pointed out, that as the electric light may be easily obtained of a brilliancy equal to 520 wax candles, three such electric lights, placed at two inches from a given small surface, would render it as bright as when it is illuminated by mean sunshine.

It was thence inferred, that a stratum occupying the entire surface of the sphere of which the earth's distance from the sun is the radius, and consisting of three layers of flame, each $\frac{1}{1000}$th of an inch in thickness, each possessing a brightness equal to that of such an electric light, and all three embraced within a thickness of $\frac{1}{40}$th of an inch, would give an amount of illumination equal in quantity and intensity to that of the sun at the distance of 95 millions of miles from his centre.

It was then shown, that were such a stratum transferred to the surface of the sun, where it would occupy 46,275 times less area, its thickness would be increased to 94 feet, and it would embrace 138,825 layers of flame, equal in brightness to the electric light; but that the same effect might be produced by a stratum about nine miles in thickness, embracing 72 millions of layers, each having only a brightness equal to that of a wax candle.

The various possible causes of the light proceeding from the lu-

minous envelope of the sun were then considered; and an attempt was made to show that the shining particles in that envelope may possibly be minute luminiferous organisms, floating in an elastic atmosphere, each emitting only a small amount of phosphorescence,—the enormous flood of splendour emanating from the surface of the medium being due to the combined action of these individually feeble agents.

The following Gentlemen were duly elected Ordinary Fellows:—

Hon. Lord Neaves.
Dr Penny, Glasgow.

Monday, 18*th February* 1856.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read:—

1. On certain cases of Binocular Vision. By Professor William B. Rogers. Communicated by Professor Kelland.

The object of this paper was to ascertain, by a geometrical construction, the optical appearance presented by the binocular vision of a straight line and a circle, or of two straight lines. The problem discussed was, accordingly, the geometric one of the intersection of a cone with a plane, or of two cones with each other: and the conclusion arrived at was that the apparent image is always a conic section. The author took no account of the *perspective* of the presented combination of images, nor of the union or disunion of the extremities of the respective images when their lengths are different. Nor did he allude to the mode by which the mind arrives at connected conclusions, from separate examination by the eye, whether by retention of images on the retina, or by the action of the memory, or otherwise. In anticipation of the introduction of such subjects, which the author has discussed in three papers, printed in Silliman's Journal of last year, Sir D. Brewster addressed the following letter to Prof. Kelland, which puts some of these questions in a striking point of view, and is of considerable interest:—

"My dear Mr Kelland,—I observe that Professor Rogers is to

read a paper on *Binocular Vision* at the Royal Society on Monday. As he has published his experiments and views on this subject in *three* articles in Silliman's Journal for *July*, *October*, and *November*, 1855, I presume that the paper he is about to read will contain the same views. I regret that I cannot be at the meeting on Monday to defend my theory of the Stereoscope against his objections to it; which are founded on an inaccurate perception of the phenomena, and stand in direct opposition to the *Law of Visible Direction*, which I have placed beyond a doubt, and which, I believe, is universally admitted.

"Mr Rogers maintains that *two lines* of unequal length, AB, *ab*, for example, *ab* being the shortest, can be made to coalesce perfectly, *i.e.*, that when the points A *a* are united by distinct vision, B and *b* are also united. Now, when the optical axes are converged, on A*a* *united* and seen *distinctly*, B and *b*, the other ends of the lines, are seen *indistinctly*, and, therefore, the observer cannot *see* them united, unless by running the point of distinct vision from A to B, when he will see them united. But when he is thus seeing these points B and *b* united, A and *a* have separated till the eye returns and unites them as before. This is the true process which goes on, and the *apparent* union of the lines thus effected is aided by two causes which Mr Rogers does not seem to have noticed. The eye runs from A to B and back again in less than one-third of a second (the duration of the impression of light upon the retina), so that the impression of A and *a* united *remains* when the eye is actually seeing B and *b* united. The other cause is merely an auxiliary one, and is not necessary to the *apparent* union of the line. It is the mental recollection of the union of A and *a* when the eye has passed in an instant to join B *b*. I lay no stress, however, upon this fact, as it is only a *physical* one, on the supposition that a recollected impression is the result of a visual sensation.

"If two unequal lines can be united and perfectly coalesce, then *two separate visible points* would have their pictures on the retina coincident; or, what is the same thing, a *line* joining two points, *a* and *b*, would have a *single point* for its image on the retina; and, what is still more absurd, *two different points* of the retina would have the same line of visible direction!

"When the difference between the two lines AB and *ab* exceeds a certain quantity, the apparent coalescence, produced by the causes

I have mentioned, entirely disappears, and it is then easy to convince one's self that the ends B and *b* are not only extremely indistinct, but completely separated when the optic axes are converged upon A and *a* united and seen distinctly.

"You will oblige me by reading these few and hurried observations to the Society. I differ with Mr Rogers on many other points to which I shall have occasion to refer in a treatise *on the Stereoscope* which will soon be published. I am, &c.

"D. Brewster.

"St Leonard's College, St Andrews,
February 16, 1856."

2. Theory of the Free Vibration of a Linear Series of Elastic Bodies. Part I. By Edward Sang, Esq.

Some remarkable Specimens of Photography were exhibited.

The following Gentleman was elected an Ordinary Fellow:—

Dr Laycock, Professor of the Practice of Medicine.

The following Gentleman was elected an Honorary Fellow:—

Henry D. Rogers, Esq., State Geologist of Pennsylvania, U.S.

Monday, 3d March 1856.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. Observations on the Diatomaceous Sand of Glenshira. Part II. Containing an Account of a number of additional undescribed Species. By William Gregory, M.D., F.R.S.E., Professor of Chemistry in the University of Edinburgh.

The author, after referring to his former paper on this subject, stated that he had continued the investigation, and that the number of undescribed forms besides those formerly figured had proved so large, that the present paper does not conclude the subject, but that

a good many forms remain for a future communication. He added, that even now, after he had explored 600 slides of it, new forms were still occasionally found.

He then gave a list of about thirty additional *known* species, which had been noticed since the former paper was read, many of them having been last year described by himself as new fresh-water species, and others not having been yet described, but to be described and figured in vol. ii. of Smith's *Synopsis*. These are:—

Amphora membranacea.
„ hyalina.
„ salina.
Cymbella sinuata.
Amphiprora paludosa.
Campylodiscus Ralfsii.
Actinocyclus radiatus.
Actinocyclus (sp. ?) This is a species to be figured in Vol. II. of the Synopsis, but I do not know how it is named.
Actinoptychus duodenarius (new to Britain ?)
Nitzschia bilobata.
Eupodiscus tenellus, Brib. (new to Britain ?)
Navicula Westii.
„ Hennedii.
„ Pandura, Brib.
„ rostrata.
Pinnularia megaloptera.
„ biceps.
„ linearis.
„ subcapitata.
„ gracillima.
Pleurosigma distortum.
„ intermedium.
Gomphonema subtile.
Diatomella Balfouriana.
Orthosira spinosa.
„ mirabilis.

He stated that he had actually found and sketched the last two forms in this deposit three years ago, but had not been able to study them fully, till after they had been found and named, the former by Drs Greville and Balfour, and Professor Smith, the latter by Mr Okeden. He had also found both these forms in soils from South America, and gave his reasons for suspecting *O. mirabilis* to be an abnormal state of *O. spinosa*.

He then proceeded to describe the following new species, of which very exact drawings by Dr Greville were exhibited:—

1. Navicula rhombica, n. sp.
2. Navicula maxima, n. sp.

Both of these had been figured in the former paper, but were now better understood. *N. rhombica* occurs in packs, like packs of cards.

3. Navicula formosa, n. sp.
4. „ pulchra, n. sp.
5. „ Macula, n. sp.
6. „ latissima, n. sp.
7. „ quadrata, n. sp.
8. „ solaris, n. sp.
9. Navicula Hennedii, Sm., of which the deposit yields very fine specimens.
10. Navicula angulosa, n. sp.
11. „ Pandura, Brib. ?
12. „ nitida, Sm. ?
13. „ splendida, n. sp.
14. „ incurvata, n. sp.

Nos. 11, 12, 13, and 14, form a very remarkable panduriform group, the first two having entire costæ, like *Pinnularia alpina*, the last two moniliform striæ. The author, on this account, names the first, No. 11, *Navicula*, after De Briberson, and the second doubtfully, as no description of *N. nitida*, Sm., has yet appeared. The two others are quite new. The author here stated that he had found in this deposit *N. didyma* with costæ, so that he considers it possible that all these forms may belong to only one species; but the point requires investigation.

15. Navicula clavata, n. sp.
16. Pinnularia longa, n. sp.
17. „ fortis, n. sp.
18. „ Ergadensis, n. sp.
19. „ inflexa, n. sp.
20. „ acutiuscula, n. sp.
21. Stauroneis amphioxys, n. sp.
22. Cocconeis distans, n. sp., inaccurately figured in Part I.
23. Cocconeis costata, n. sp., a more characteristic specimen than that figured in Part I.
24. Cocconeis radiata, n. sp.
25. „ lamprosticta, n. sp.
26. Amphora elegans, n. sp.
27. „ rectangularis., n. sp.
28. „ obtusa, n. sp.
29. „ lineata, n. sp.
30. „ plicata, n. sp.
31. „ biseriata, n. sp.
32. „ crassa, n. sp.
33. „ Grevilliana, n. sp.

The three last form a very remarkable group, either a subgenus or a new genus. To this group belongs also *Amphora Arcus*, of which a part is figured in Part I.

34. Campylodiscus simulans, n. sp.

The author showed that this form so much resembles, in its markings, *Surirella fastuosa*, as figured in Part I., that these two genera probably form but one.

35. Campylodiscus bicruciatus, n. sp.
36. Nitzschia distans, n. sp.
37. „ insignis, n. sp.
38. Nitzschia socialis, n. sp.
39. Amphiprora minor, n. sp.
40. „ recta, n. sp.

The remaining forms will be described on a future occasion.

2. Theory of the Free Vibration of a Linear Series of Elastic Bodies. Part II. By Edward Sang, Esq.

I. The first part of this paper was occupied with the discussion of the validity of Newton's Theory of the Propagation of Sound. In order to discover the velocity of sound, Newton supposes a series of particles ranged in a straight line to be set to vibrate all equally and isochronously, but the epoch of vibration to vary gradually along the line; and he then investigates the circumstances under which such a vibration is possible. The true result of the investigation is this,—that if the two extreme particles be kept vibrating by some

external influence, and if all the intermediate particles be fairly started with the velocities appropriate to their positions in the series, the constrained vibrations of the two extreme particles, aided by the elasticities of the intermediate parts, are sufficient to maintain the vibrations of those parts.

Neither the premises of this investigation nor the conclusion have the slightest reference to the problem "*to discover the velocity of sound.*" In order to represent the conditions of this problem, we must suppose that, the row of particles being at rest, the particle at one end receives a sudden impulse, and we must seek to trace the manner in which this impulse is propagated along the chain; and it is evident that there is not one point of connection between Newton's theory and such premises.

Having failed in many attempts to separate the variables which enter into the analysis, the author of the paper was again led to consider the question by the construction of the Manchester and Liverpool railway; for the question in hand is identical in its character with this one, "*to investigate the effect of a concussion on a train of waggons connected by elastic buffers;*" but although the practical importance of the subject induced him to make more strenuous efforts, the difficulties of the integrations again baffled him. In the month of November last, however, being again led to reconsider the problem, he was so fortunate as to discover an easy method of separating the variations so as to render them integrable, and thus to bring the matter within the scope of strict analysis.

The same method is applicable to problems of a higher class. Thus if we suppose a number of planets, of which the attractions are proportional to the distances, although these attractions be not proportional to the masses of the attracting bodies, the integrations can be effected. The result of the investigation shows that such a planetary system would have as many nuclei as planets,—one of these nuclei being the centre of gravity; each of the other nuclei would describe an ellipse around the centre of gravity in its own periodic time; and thus the motion of any one planet would be the compound of as many elliptic motions, less one, as there are planets, superadded to the rectilineal motion of the centre of gravity.

It was mentioned that this is the first instance in which *the* PROBLEM *of* THREE BODIES has been resolved when the resultants of the attractions do not all pass through one point.

II. The motions of a linear elastic series form but a case of the preceding problem. It was shown that the vibration of a series of n equal bodies are compounded of $n-1$ distinct vibrations, performed in times which are proportional to the secants of the multiples of the nth part of a quadrant. These times, then, are all incommensurable, so that a perfectly elastic series of n bodies could never again return to its original state; nay, not even two of the bodies could ever again be simultaneously at the corresponding parts of their orbit.

This incommensurability of the periodic times presents a great obstacle to a theoretic estimate of the velocity with which an impulse is transmitted, since it is difficult to decide what phenomenon should be defined as constituting the transmission; and since the equations to be evolved contain the sines of angles of which the ratios are incommensurable. Thus, although the equations enable us to compute the state of the system at any prescribed time, we are unable to resolve generally the converse question,—At what time is any one body in a given state?

One very important deduction is, that a blow on one end of an elastic series evokes every oscillation of which the series is susceptible, and that, therefore, no pure or musical sound can ever be produced by a perfectly elastic body. A simple oscillation can only be produced by the concurrence of twice as many initiatory conditions as there are particles. Now there is no doubt that the vibrations of elastic bodies do resolve themselves into simple or very slightly complicated vibrations, so that the viscidity, imperfect elasticity of the parts, or some analogous quality of the material, must operate.

The time needed for the transition from an infinitely confused to a simple vibration, and the manner in which that transition is accomplished, may lead to the explanation of *consonant* sounds; and the existence of some of the higher classes of vibrations with that vibration which gives the musical pitch, may occasion the peculiar phenomena of vowel sound.

Monday, March 17, 1856.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read:—

1. An Account of some Experiments on certain Sea-Weeds of an Edible kind. By John Davy, M.D., F.R.S., Lond. and Edin., &c.

The sea-weeds examined by the author, reported on in this paper, were the following:—Carrigeen Moss (*Chondrus crispus*), Dulse or Dylisk (*Rhodymenia palmata*), Sloke or Laver (*Porphyra laciniata*), Tangle (*Laminaria digitata*), Doughlaghman (*Fucus vesiculosus*).

The results, imperfect as they are, it is stated, are offered as a contribution, with the hope of inducing others more favourably situated to turn their attention to a subject hitherto, in a chemical point of view, singularly neglected.

Chondrus crispus was found to be composed of about 28·5 parts by weight soluble in cold water, of 49 soluble in boiling water, and of about 22·5 per cent. resisting both infusion and decoction. The part dissolved by boiling water had the properties of gelatine; that by cold water of mucilage.

In Dulse no gelatine was detected. Acted on by cold, followed by boiling water, it lost about 52 per cent. Its colouring matter has the property of combining with alumina, and is precipitated by this earth from its infusion.

Sloke or Laver was found to be very similar to the preceding. Acted on by cold and by boiling water it lost about 50 per cent.

Tangle also bore a considerable resemblance to the preceding, judging from the properties of its infusion and decoction. The stalk yielded less soluble matter to water than the fronds, only about 13·5 per cent.

Fucus vesiculosus lost by infusion about 16 per cent., and by subsequent decoction about 39 per cent.

In all these Algæ iodine was detected in the matter extracted by infusion and decoction, and in the residual matter: it was found also in the water used to wash the weeds, for the purpose of removing

the salt adhering, derived from the sea, in which they grew. The proportion of iodine, as indicated by testing the saline matter obtained from the ash, varied in each. It was found very abundant in tangle, with a trace of bromine, and especially in the stem. In the ash of each also a notable proportion of phosphate of lime was found, with more or less of carbonate of lime and magnesia.

In conclusion, the author offers some general remarks—1*st*, On the absence in these algæ of starch, fatty or oily matter, and saccharine matter. 2*d*, On the necessity of minute research to determine the exact nature of their several proximate principles. 3*d*, On the loss sustained by washing the weeds preparatory to their being used as food, thereby diminishing their value. 4*th*, On their value as articles of food, if the nitrogen they afford may be considered as a criterion of their nutritive power: a table is given showing the proportion of this substance in each, as determined by Professor Apjohn, exhibiting the unexpected result, that these esculent algæ are actually richer in nitrogen than flour of the first quality. 5*th*, On the advantage likely to be derived, especially by persons of the labouring class, in regard to health, from their more general use. 6*th*, On their efficacy as manures, on account of the nitrogen which they yield in the act of decomposition, and the inorganic compounds they supply to the soil. *Lastly*, On the part they perform in the economy of nature—in purifying sea-water by removing excess of carbonic acid, and probably azote—and in separating and storing up, not only most of the inorganic elements which exist in terrestrial plants, but others, especially those powerful medicinal agents, iodine and bromine, as if specially for the use of man.

2. On the Deflection of the Plumb-Line at Arthur's Seat, and on the Mean Density of the Earth. By Lieutenant-Colonel James, R.E. Communicated by Professor Forbes.

The author states that the results of the Trigonometrical Survey of Great Britain are now nearly ready for publication, and that he has deduced from them the most probable measures which they afford of the length of a meridian, and the figure of the earth.

After determining the most probable spheroid from all the astronomical and geodetical operations in Great Britain, it has been found that the plumb-line is sensibly deflected at several of the trigono-

metrical stations; but in almost every case the physical cause of such irregularity may be with probability inferred.

In the case of the station at the Edinburgh Observatory, and on the summit of Arthur's Seat, where the latitudes inferred geodetically in consistency with the entire survey are compared with the direct astronomical determinations, a deviation of the plumb-line towards the south, to the extent of between 5″ and 6″ is manifested. The exact latitudes are as follow:—

	Observed.	Calculated.	Difference.
Observatory, Calton Hill,	55° 57′ 23″·20	55° 57′ 17″·57	5″·63
Arthur's Seat, summit, .	55° 56′ 43″·71	55° 56′ 38″·44	5″·27

From this it is evident that the discrepancy occurring at the Observatory cannot be ascribed to the deflecting attraction of Arthur's Seat, where it exists almost equally. Colonel James attributes it in both cases to the effect of the hollow of the Firth of Forth to the north, together with the mass of high ground to the south, including the Pentland and Lammermoor ranges. On actually calculating the effect of the configuration of the ground within a radius of 15 miles, about 2″·6 of the deviation is accounted for; and the writer believes that the mountainous country beyond may farther sensibly increase the effect.

With a view to determine the strictly local attraction of Arthur's Seat, three stations were fixed nearly on a common meridian line, passing through the summit of the hill. These are marked N, A, and S. The station N (most northerly) is in the vicinity of St Anthony's Chapel, A is almost on the highest point of the hill, S is situated on the knoll above Sampson's Ribs. 220 double observations of stars were made at each station in September and October 1855 with Airy's Zenith Sector.

The difference of astronomical latitude of the stations N and S is 42″·56.

The difference of the geodetical latitudes is 38″·46.

The difference of these numbers, or 4″·10, measures the double deflection of the plumb-line at the two stations due to the attraction of the interposed hill.

The accurate system of contours which have been carried round the hill allows the calculation of the attraction of all its parts at the two stations N and S, to be performed with the utmost nicety, on the supposition of its being of homogeneous material. By in-

cluding the effect of all the inequalities of the ground within a radius of 6000 feet (or rather more than a mile) around each of the stations, and denoting by x the unknown ratio of the density of the hill to that of the entire globe, these equations are obtained:

Deflection at South station,	. . .	$= 4{\cdot}197\ x$ North.
" Arthur's Seat,	. . .	$= 0{\cdot}607\ x$ South.
" North station,	. . .	$= 3{\cdot}710\ x$ South.

by the solution of which the ratio of the density of the hill to that of the whole earth is as ·5245 to 1.*

By extending the radius of sensible attraction considerably beyond 6000 feet, and calculating the effect of the surrounding country in the same manner on the plumb-line at the three stations, this value of the relative density of the globe is somewhat modified. The ratio is then ·5348 to 1.

From direct experiments on the specific gravity of the rocks of Arthur's Seat, Colonel James infers the mean density of the hill to be 2·75 times that of water; whence the earth's density comes out

$$5{\cdot}14,$$

with a probable error of 0·07.

3. On the Possibility of combining two or more independent Probabilities of the same Event, so as to form one definite Probability. By Bishop Terrot.

In this paper the author showed that, a and e being independent probabilities of the same event, the expression $a+e-a\,e$, given in the article Probability in the *Encyclopædia Metropolitana* as the value of their combined force, was erroneous. For if $a+e-a\,e$ be the probability of the occurrence of the event, then $\overline{1-a}+\overline{1-e}-\overline{1-a}\cdot\overline{1-e}$ or $1-a\,e$, is the probability of its non-occurrence. Whereas the probability of non-occurrence derived directly from the expression $a+e-a\,e$ is $1+a\,e-\overline{a+e}$.

It was then shown, that if the *ratio only* of equally probable cases in two or more probabilities were given, no definite probability could be derived from their composition; but that if the two given probabilities $\frac{p}{r}$ and $\frac{q}{s}$ indicate not merely the ratios, but the *actual*

* The outstanding abnormal deflection of the plumb-line (assumed to be equal at the three stations) amounts to $4''{\cdot}72$.

numbers of favourable and unfavourable cases or hypotheses, their compound force is properly expressed by $\frac{p+q}{r+s}$.

Under both of these conditions, the second given probability increases or diminishes the force of the first, according as the fraction expressing the second is greater or less than that expressing the first. When the ratios only are given, then the increase or diminution is *indefinite*. When the actual numbers are given it is *definite*.

In conclusion, it was questioned whether $\frac{1}{2}$ was a proper expression for the probability derived from total ignorance, and whether this would not be more properly expressed by the indefinite fraction $\frac{0}{0}$. It was shown that such *a priori* probability had no effect upon the force of a subsequently admitted probability.

The following Gentleman was duly elected an Ordinary Fellow:—

THOMAS CLEGHORN, Esq., Advocate.

The following Donations to the Library were announced:—

Exhibition of the Works of Industry of all Nations, 1851. Reports by the Juries on the Subjects in the Thirty Classes into which the Exhibition was divided. 4 vols. fol.—*From H. F. Talbot, Esq.*

Journal of the Proceedings of the Linnæan Society. Vol. i., No. 1. 8vo.—*From the Society.*

American Journal of Science and Arts. Vol. xxi., No. 61. 8vo. —*From the Editors.*

Journal of the Statistical Society of London. Vol. xix., Part 1. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society. Vol. xii., Part 1. 8vo. —*From the Society.*

Die Fortschritte der Physik im Jahre 1852. Dargestellt von der Physikalischen Gesellschaft zu Berlin. 2e Abtheil. 8vo.—*From the Society.*

Annalen der Königlichen Sternwarte bei München. Bd 8. 8vo.—*From the Observatory.*

Tables showing the number of Criminal Offenders in England and Wales, in the year 1854. Fol.—*From the Home Office.*

A Collection of Charts published at the Hydrographic Office, London.—*From H. M. Admiralty.*

Monday, 7th April 1856.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On Atmospheric Manoscopy, or on the direct Determination of the Weight of a given bulk of Air with reference to Meteorological Phenomena in general, and to the Etiology of Epidemic Diseases. By Dr Seller.

The intention of the author in this communication is to recommend the daily determination of the weight, by direct means, of some considerable bulk of atmospheric air. This subject has become of interest to medical observers, owing to the belief which has arisen, on hardly sufficient grounds, that during the prevalence of epidemics the air is of greater weight than usual. The late Dr Prout, whose researches on the specific gravity of air give authority to his opinion, was led to conclude, from the greater weight observed to belong to a given bulk of air at the first outbreak of Asiatic cholera in London during the year 1832, that a malarious principle, heavier than the atmosphere itself, was at that time slowly diffusing itself through the atmosphere. Other observers in the succeeding cholera-epidemics have contented themselves with determining the daily weight of a cubic foot of air by calculation from the recorded barometric pressure, temperature, and humidity. The author endeavours to show that this last method does not meet the case. He says that, in order to detect foreign elastic matter in the atmosphere, it is necessary to weigh a certain bulk of air; for if the foreign matter be lighter than the atmosphere itself, it increases the general pressure, while it renders a given bulk of air lighter than usual; and though, when heavier than the atmosphere itself, it both increases the general pressure and the weight of a given bulk of air, yet that the former effect may escape detection, while the latter is distinct.

Dr Seller further insists that, even when no foreign elastic matter exists in the atmosphere, there is reason to doubt if the specific gravity of the air near the earth's surface is uniformly dependent on the general pressure, the temperature, and the humidity. Among the grounds for this doubt, he refers to the vast extent of the atmosphere, the infinity of circumstances constantly tending to disturb its equilibrium, the considerable periods of time required on many occasions to restore that equilibrium, if it can be said to have an ordinary equilibrium, and, in particular, to the peculiar laws, in some degree antagonistic of gravity and therefore of pressure, observed to affect the distribution of gaseous bodies, whether placed simply contiguous to each other, or already in a state of mixture. He concludes, therefore, that the only mode in which any useful result in this subject, either as respects the etiology of epidemic diseases or meteorological phenomena in general, can be obtained, is by following the example of Prout, and determining daily, by a direct process, the weight of some certain volume of air. Neither does he regard the efforts at present making by chemists to detect foreign bodies in the atmosphere by means of chemical tests as necessarily superseding the proposal to determine its daily variations of density by direct means.

Dr Seller considers the usual method of weighing air by comparing the weight of an exhausted vessel with that of the same vessel filled with air, as involving too much trouble for daily use. He suggests that a near approximation to an exact result may be made by observing the difference between the weight of a light body *in vacuo* and its weight in air; the former being a constant quantity for every place, while the latter varies in exact conformity with every change which occurs in the density of the air. The larger such a light body is, and the greater the difference of bulk between it and its counterpoise, the nearer is the approximation to an exact result, while there is the less need for extreme nicety in the process. The counterpoise, with the exception of the mere grain weights, should be capable of easy admeasurement; for example, cubic inches of a heavy metal. The sum of the weights of the body and its counterpoise *in vacuo*, diminished by the sum of their weights in air, is to be divided in the ratio of their bulks for the weight of air which each displaces. The weight of a body *in vacuo*, independently of its weight in air, can be ascertained with precision in proportion as the following data, at a certain temperature, are exactly known, viz., the weight *in vacuo* of

a given measure of distilled water, the volume of distilled water equal to the bulk of the body, the weight of the body when immersed in distilled water, allowance being made for the difference between the weight of the counterpoise *in vacuo* and in air.

The chief difficulty is to procure a body of sufficient size not too heavy for a delicate balance. It seems not improbable that a material may be found which, when formed into a globe or a drum, and filled with air merely for the sake of lightness, shall not exceed a pound in weight, and yet may be of such a size as, with a balance turning with the tenth of a grain, may, under the occasional correction of exact methods, enable those who engage in meteorology merely for the sake of occupation, to add to their register a near approximation to the daily density of air. If such a body, equal to or exceeding a cubic foot in volume, cannot be provided with the requisite qualities, namely, lightness, permanence in figure, impermeability to air and moisture, and the being susceptible of having its expansions and contractions, under changes of temperature, reduced to rule, a glass globe capable of displacing 600 cubic inches of air, with a little more pains and attention, can be made to serve the purpose recommended in this communication.

2. Researches on Chinoline and its Homologues. By C. Greville Williams. Communicated by Dr T. Anderson.

In this inquiry, which is an extension of an investigation published in the Transactions for last year, the author examines the connection which has been said to exist between chinoline and quinine, and shows that they bear no simple relation to each other. He states, also, that the supposed analogy between the action of heat on quinine and the hydrated oxide of tetramethyl-ammonium does not exist, and that the assertions which have been made regarding the possibility of the formation of quinine from the leukol of coal-tar are founded on error. He then, after showing that chinoline from cinchonine had not previously been obtained in a state of purity, gives the history and composition of the platinum, gold, and palladium salts; also the nitrate, bichromate, and binoxalate.

He describes two new classes of salts formed by the chlorides of cadmium and uranyl with organic bases, and gives the analysis of

their compounds with chinoline. Then follows a determination of the vapour density of chinoline, and an examination of the action of the iodides of the alcohol radicals on the base, and some of the products of the decomposition of the hydriodates of the ammonium bases so formed.

He also examines the chinoline series as it is obtained from coal-tar, and proves the presence, in addition to chinoline, of lepidine, and a new base, "cryptidine."

In the course of the investigation, the following compounds were analysed :—

Platinum salt, chinoline, . .	$C^{18} H^7 N, HCl, + Pt Cl^2$
Gold, ...	$C^{18} H^7 N, HCl, + Au Cl^3$
Palladium, ...	$C^{18} H^7 N, HCl, + Pd Cl$
Cadmium, ...	$C^{18} H^7 N, HCl, + 2 Cd Cl$
Uranium, ...	$C^{18} H^7 N, HCl, + (U^2 O^2) Cl$
Nitrate of chinoline, . .	$C^{18} H^7 N, + NO^5 HO$
Bichromate, ...	$C^{18} H^7 N, + 2 (Cr O^3) HO$
Binoxalate, ...	$C^{18} H^7 N, + 2 (C^2 O^3 HO)$
Platinum salt, methyl-chinoline, .	$C^{20} H^9 N, HCl, + Pt Cl^2$
Hydriodate ethyl-chinoline, . .	$C^{22} H^{11} N, + HI$
Platinum salt, ethyl-chinoline, .	$C^{22} H^{11} N, HCl + Pt Cl^2$
Hydriodate amyl-chinoline, . .	$C^{28} H^{17} N, HI$
Platinum salt, amyl-chinoline, .	$C^{28} H^{17} N, HCl + Pt Cl^2$
Platinum salt, lepidine, from coal-tar,	$C^{20} H^9 N, HCl + Pt Cl^2$
Hydriodate ethyl-lepidine, . .	$C^{24} H^{13} N, HI$
Platinum salt, ethyl-lepidine, .	$C^{24} H^{13} N, HCl + Pt Cl^2$
Platinum salt, cryptidine, . .	$C^{22} H^{11} N, HCl + Pt Cl^2$

3. On Fermat's Theorem. By H. Fox Talbot, Esq., F.R.S.

The author gave a simple demonstration of the proposition, that $a^n = b^n + c^n$ is impossible, when $n > 2$, and either of the numbers, a, b, c, a prime number.

4. On the Transmission of the Actinic Rays of Light through the Eye, and their relation to the Yellow Spot of the Retina. By George Wilson, M.D.

In 1849 the learned Swiss philosopher Wartmann stated, in his "Deuxième Mémoire sur le Daltonisme," p. 40, that "the eye

arrests the chemical radiations which accompany the more refrangible rays." He founded this conclusion on experiments made with guaiac resin; but as this substance is by no means very sensitive to actinic influence, it seemed desirable to test the question whether the eye can transmit the chemical rays of light, by an appeal to those highly impressible *actinolytes* (as they may be called) which the recent progress of photography has revealed to us.

The necessary trials were kindly made for me by Messrs Dick and Spiller of London, and their results, which are opposed to those of Wartmann, were published last autumn in the Appendix (p. 166) to my Researches on Colour-Blindness.

I now lay upon the Society's table photographs of small objects, on glass and paper, produced by rays which, before reaching the sensitive surfaces, had traversed the transparent humours of an ox's eye. These photographs were obtained by the gentlemen I have named in the following way:—

"An ox-eye was prepared by cutting away the sclerotic until the choroid came into view; a circular aperture of one-eighth of an inch in diameter was then made through this membrane and the retina, which laid bare the vitreous humour at a point opposite to that where the light enters. The eye was then supported in the brass mounting of a photographic lens (*i.e.*, a brass tube adapted to the front of a camera), resting at the posterior end on a ring of cork which fitted tightly into the tube, and retained in front by a diaphragm, so as to permit the cornea to protrude. From the arrangement of the fittings, we are quite satisfied that no light excepting that which passed through the eye could enter the camera.

"Within the dark box, a strip of black paper, with a diamond-shaped or rhombic aperture occupying the greater part of its breadth, was extended across in front of the prepared collodion glass plate, so as to throw its image on the latter, in the event of any chemical rays finding their way to it. The camera was then pointed to the sky (the morning being bright and the sun shining), and the plate exposed for fifteen seconds. On developing with solution of sulphate of iron, a very decided picture appeared. The glass plate which accompanies this paper was the result of twenty seconds' exposure.

"The conclusion derived from this experiment, although perfectly

satisfactory to those who arranged the apparatus, is open to the objection, on the part of others, that the picture does not present any *prima facie* evidence of its being the result of rays which passed through the eye. We therefore endeavoured to copy photographically the actual image which is depicted on the retina. To do so, another bullock's eye was carefully dissected, so as to open a circular space of about three-eighths of an inch in diameter at the back of the eye, the retina was removed, and a very thin film of glass, in shape like a watch-glass, substituted for it; this supported the vitreous humour in its original position, and served also to prevent its contact with the photographic paper placed behind to receive the impression. In another trial, the retina was left untouched, without altering the ultimate result.

" Iodide of silver paper was then made sensitive to light by a wash of gallo-nitrate of silver, and used as in the Talbotype process, small squares of the wet paper being successively applied to the back of the thin glass film, and exposed for varying periods (one minute on an average) to the different objects to which the bullock's eye was presented. On developing the latent images with strong gallo-nitrate of silver, very distinct pictures were obtained *of a key* and of a *spotted window curtain*. These negative pictures are inclosed. It is thus beyond a doubt that the chemical rays penetrate the humours of the eye, and impinge upon the retina.

" Allan B. Dick.
" John Spiller."

It thus appears that the actinic or chemical rays are not arrested in their passage across the chamber of the eye; and it becomes an important question how they will affect the general surface of the retina on which they impinge, and what share they have in producing vision. Into this problem, as a whole, however, I do not purpose to enter: the question I alone consider is the change which the actinic rays will undergo when they fall upon that peculiarly organized portion of the human retina which anatomists distinguish as the " yellow spot." This " spot," almost peculiar to man, presents a diameter of about $\frac{1}{12}$th inch, and occupies the bottom of the eye, in the exact axis of its transparent humours. It is more transparent than the rest of the retina, and has long been recognized as the seat of most perfect vision in the eye of man. I have elsewhere drawn

attention to the effect which it must have as a coloured medium on the light which reaches it,* and on the actinic rays which traverse it. I wish now to carry these views a step further, in connection with the reflection of light from the choroid through the retina, which was discussed before the Society last session, in a paper "*On the Eye as a Camera Obscura*," and which, before and since, has been largely made the subject of independent inquiry by foreign and British observers. In particular, Professor Goodsir has shown, in a lecture delivered in the University of Edinburgh last June, and since published,† that it is not merely the case that light traverses the retina to the choroid, and is then reflected so as to return through the retina, but that *it is only the rays thus returned which produce a luminous sensation.* The light, therefore, which traverses the yellow spot, and is then reflected forwards on the choroidal extremities of the optically sensific constituents of the retina, must have been deprived, to a greater or less extent, of its actinic rays, before it determines a luminous sensation, unless the portion of the retina under notice differ from all other yellow transparent media known to us, in not arresting the chemical rays. If it be not in this respect exceptional, then the theory of perfect human vision may be simplified by the exclusion from consideration of the actinic rays; and one use of the yellow spot, for which it has hitherto baffled physiologists to find a use, may be to extinguish these radiations. I offer this only as a suggestion, the value of which must be determined by testing the chemical power of light after it has traversed the yellow spot,—an experiment which only those few anatomists can try who have the opportunity of examining the human eye soon after death.

I will only, therefore, remark further, in reference to the absorption of the actinic rays by the yellow spot (with which this paper is chiefly concerned), that the views of those who have described visual impressions on the retina, as phenomena of the same kind as photographic impressions on surfaces charged with salts of silver, or other actinolytes, must fall to the ground if the actinic rays of light are stopped before reaching the optically sensific constituents of the retina. The similar opinion, also, that "spectral vision," and other abnormal peculiarities of sight, are phenomena of the same kind as

* Researches on Colour Blindness, p. 83.

† Edinburgh Medical Journal, October 1855.

the development (as it is technically called) of latent photographic images, must, for the reason mentioned, be abandoned. It will still, of course, be competent to compare normal and abnormal vision with photographic effects, as phenomena displaying analogy, though not affinity.

To one other relation of the retina to light, I make the briefest reference. If only those rays which are reflected from the choroid produce, by their impact on the retina, the objective perception of light, and if the depth of tint of the yellow spot be considerable, and its colour at all homogeneous, then perfect vision must be exercised by yellow, not white light. But if this be the case, we should be unconscious of red and blue when seeing best, or at least should receive from them an impression very different from that which they occasion when they affect the general surface of the retina. I forbear, however, to speculate on this, seeking rather to direct the attention of the few anatomists who have the opportunity of investigating the subject to an examination of the chromatic as well as the actinic relations of the yellow spot, than desiring to dogmatize on either.*

P.S.—I take this opportunity of expressing my regret, that in a postscript, added after it was read, to the paper in the Transactions of the Society for last session, "*On the Eye as a Camera Obscura,*" I inadvertently misstated the views of Professor Goodsir on the retina referred to in this communication, and had not an opportunity of amending the statement before the Transactions were published. I have, therefore, to request those who wish to do justice to Mr Goodsir, to consult his lecture on the Retina, published in the "*Edinburgh Medical Journal,*" for October 1855.

The following Donations to the Library were announced:—

The Assurance Magazine, and Journal of the Institute of Actuaries, Vol. vi., Part 3. 8vo.—*From the Institute.*

Proceedings of the Ashmolean Society, 1855. 8vo.—*From the Society.*

* According to some eminent authorities, there is an aperture in the centre of the yellow spot. If such be the case, light may pass and repass by it without being coloured; but as such light will in both journeys fail to impress the retina, it cannot contribute to the production of a luminous sensation.

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. N. S., No. 52. 8vo. —*From the Society.*

Journal of the Asiatic Society of Bengal. N. S., Nos. 5 & 6. 1855. 8vo.—*From the Society.*

Bulletin de la Société de Géographie. 4me Série. Tome x. 8vo. —*From the Society.*

Verhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. Bd xxiv., Supp. Bd xxv., Heft 1. 4to.—*From the Academy.*

Smithsonian Contributions to Knowledge. Vol. vii. 4to.—*From the Smithsonian Institution.*

Abhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt. Band 2, 1855. Fol.

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1855. No. 1. 8vo.—*From the Institute.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. Bd xvii., Heft 3. 8vo.—*From the Academy.*

Coup d'œil Géologique sur les Mines de la Monarchie Autrichienne. Par Fr. de Hauer & Fr. de Fœtterle. 8vo.—*From the Authors.*

Monday, 21*st April* 1856.

Sir DAVID BREWSTER, K.H., V.P., in the Chair.

The following Communications were read:—

1. On the Prismatic Spectra of the Flames of Compounds of Carbon and Hydrogen. By William Swan, Esq.

While the prismatic spectra of the blue portions of an oil-lamp or coal-gas flame, exhibit a number of bright lines, separated by dark intervals, the spectra derived from the bright light of these flames are perfectly continuous. Apparently inconsistent results are in like manner obtained when the flames of different compounds of carbon and hydrogen are compared. Thus, lines are easily seen in the

spectrum of the flame of alcohol, which are invisible in that of the flame of oil of turpentine.

These discrepancies are shown, in the present paper, to arise from the predominance of the light of incandescent solid carbon in some flames, and its comparative absence in others: and it is also proved that in order to obtain uniform results from the flames of the various compounds of carbon and hydrogen, it is sufficient, in cases where the body contains much carbon, to convert the carbon into carbonic acid, without its previous separation in a solid form, by means of an artificial supply of air. This is conveniently effected for coal-gas by means of the Bunsen gas-lamp, which burns a mixture of gas and air; and, for other bodies, by directing a stream of air from a table blow-pipe through the flame.

When thus treated, all the compounds of carbon and hydrogen which have been submitted to experiment, were found to produce identical spectra; that of the Bunsen lamp serving as a standard of comparison.

In these spectra five principal bright lines were observed, accompanied by several smaller ones, and separated by dark intervals. One of the lines, the well known R of Fraunhofer, has been long known to coincide with the line D of the solar spectrum. Two other extremely close coincidences were discovered. One between a brilliant green line of the lamp spectrum, and the remarkable triple line *b* of Fraunhofer; and another, between a bright purple line, and the conspicuous line G of the solar spectrum.

It follows, from these experiments, that all bodies whose composition is expressed by the general formulæ

$$C_p\ H_r\ ,\ \text{or}\ C_p\ H_r\ O_s,$$

produce, in burning, perfectly identical spectra; the nature of the light being always the same, notwithstanding variations in the relative proportions of carbon and hydrogen, and the occasional presence of oxygen in the body.

2. On the Laws of Structure of the more disturbed Zones of the Earth's Crust. By Professor H. D. Rogers, of the United States.

After adverting to previous publications on the subject by himself and Professor W. B. Rogers, the author of the paper began the enunciation of the laws of structure of disturbed tracts of strata, by stating the general proposition that in all districts where the strata have been displaced from the original positions or levels in which they were deposited, they invariably have the form of one or many waves, even where, from a flatness of the undulations, they seemed to retain their original horizontality. In large areas of undulating strata, where the dips are gentle, the main or primary crust waves are very broad; but where the dips are steep, the crests of the adjacent undulations are more closely approximated, and generally the amplitude of the waves is in proportion to their flatness.

It is another prevailing feature of districts of displaced strata, that the undulations into which they have been lifted are approximately parallel, and exhibit a remarkable resemblance to those great continuous billows, which are called waves of translation. This wave-like structure was first distinctly recognised by the author and his brother in the Appalachian chain of the United States, and has been subsequently shown by them to characterize other mountain systems, such as the Jura, the Alps, and the mountainous districts of Wales and Belgium, and other countries.

Parallelism.

1. Expressing, in systematic form, the general relations of the flexures of the earth's crust to each other, the first law is that of the mutual parallelism of the waves. This prevails not only between adjacent individual flexures, but between these and the chief igneous axes of the disturbed zones, including them. The parallelism extends to the different groups of waves into which the breadth of the undulated district is divided, and subsists as well between those which are curved in their crest lines as between those which are straight. The persistency of this law of parallelism throughout the Appalachian chain, was fully exemplified in the paper. The geological maps of the United States and of Pennsylvania, soon to be published, make it obvious upon mere inspection.

2. The flexures, when the undulated belt is broad, exist in groups of waves, and the parallelism is generally more perfect between the members of a given group than between one group and another.

3. Usually where the zone of undulated strata is extensive, there are several orders of waves, as regards their dimensions, the secondary or lesser classes constituting as it were ripples on the slopes and summits of the primary or larger. These minor flexures, or subordinate rolls, are themselves parallel, but not always necessarily parallel with the principal waves upon which they lie.

Form and Gradation of the Waves.

Three essential varieties of form prevail among the great flexures of the earth's crust. 1. The most simple is that of a symmetrical wave, or one where the convex (*anticlinal*) or concave (*synclinal*) curve is of equal flexure upon both slopes. This form belongs chiefly to the flatter and broader waves, and when met with among those of steeply-inclined sides, is apt to be accompanied by an angular bending or even partial dislocation at the anticlinal or synclinal axis. 2. A second prevailing form is where one side of the wave is visibly steeper than the other. This is the normal type of flexure in the Appalachian chain, in the Jura mountains of Switzerland, and in the undulated zone of Belgium and the Rhenish Provinces. 3. The third class of flexures embraces those which exhibit an inversion or folding under of the most bent slopes of the several waves. This doubling under frequently amounts to an almost perfect parallelism of the two sides of the flexures. In such cases where the alternate convex and concave bendings are numerous, and the whole belt is closely plicated, a transverse section presents the puzzling phenomenon of strata of different ages dipping in one direction, in parallel, seemingly conformable superposition, the newer rocks underlying the older ones as frequently as they overlie them.

Conceiving a series of imaginary geometric planes to bisect the successive anticlinal and synclinal bends in a belt of undulated strata, these axis planes, as they may be called, are, in the case of the symmetrical class of waves, necessarily perpendicular; but, in the other two classes, they are inclined to the horizon, and their dip or inclination is flatter as the waves approach the form of most extreme folding with inversion. In many districts, as along the south-eastern

side of the Appalachians, and on both flanks of the Alps, these axis planes, or what is the same thing, the foldings of the rocks, incline at a very low angle, implying an excessive amount of horizontal movement at the time the strata were thus plicated and packed together.

This parallel reduplication of strata is usually attended by more or less metamorphism, amounting to that change of internal structure which is denominated cleavage; and the cleavage planes, frequently more conspicuous than the original planes of sedimentation, serve still further to conceal the flexures, and disguise the true order of superposition of the rocks.

Waves of the Crust both Straight and Curvilinear.

In the much corrugated belts, the crust waves are both straight and curvilinear. In the Appalachians there are groups of both these classes, retaining their special features throughout their entire length, which, in some instances, exceeds 100 miles. Some of the crescent-shaped waves present their convex curvature towards the region of maximum dislocation and metamorphism, while other groups are concave toward the same quarter. These different systems of waves seem to have been generated some of them from straight, others from curvilinear fractures in the earth's crust.

The Appalachian chain, regarded in the light of a long zone, or chain of groups of parallel straight and curving waves, consists of eleven sections, six of which are straight and five curvilinear, three of the latter form being convex towards the N.W., and two convex towards the S.E., the whole zone having a length of 1500, and a maximum breadth of 150 miles. Certain of the straight divisions have their anticlinal axes, or the crest lines of the undulations trending N. 15° E.; other divisions, theirs trending N. 70° E., while some of the curving sections of the chain show a deflection in the direction of their individual axes of as much as 40°. Indeed, in particular instances, the change of trend amounts to as much as 60°. So remarkable a bending without disruption, of groups of parallel anticlinals seems incompatible with the inferences of some eminent geologists, who conceive that there prevails a general relation throughout the globe between the directions of the lines and the epochs, of crust elevation; for we here find that the self-same axis, generated throughout its whole length, not merely in one geolo-

gical period, but in one brief interval of time, alters its direction to coincide successively with sundry of the different assumed systems of crust elevation.

Gradations in Flexures.

Every broad belt of undulated strata exhibits certain gradations in the form of its flexures starting from the side of maximum igneous action, as this is displayed in plutonic eruptions, or in dislocations and metamorphism. Crossing the zone, the flexures first met with are invariably of the closely plicated class, their axis planes dipping often at a low angle towards the igneous border. To these succeed more and more open waves, until, from being perpendicular, the steep far sides of the undulations become flatter and flatter in their dips, till at last they assume a slope equal and symmetrical with those of the gentler flanks. Parallel with this gradation is a progressive widening of the waves themselves, and a corresponding sinking or flattening down of the summits, until they finally disappear in imperceptible undulations. All these phenomena of gradation may be clearly discerned in every section across the Appalachian chain, traced from the S.E. towards the N.W., and a perfectly identical structure will be found to exist in the great plicated belt ranging through the Rhenish Provinces and Belgium. In truth, there is no great corrugated zone that does not display a similar law of gradation in its flexures, when these are properly traced and generalized.

Fractures in Undulated Zones.

Two classes of dislocations abound in all belts of the crust where the strata are greatly undulated. The least conspicuous, but most numerous are comparatively short faults, transverse more or less perpendicularly to the strike of the anticlinal and synclinal axes. These abound in the Appalachians and other corrugated mountain chains, and are a principal cause of the deep transvere ravines and mountain notches which intersect their ridges, and give passage to their streams. The more obvious dislocations are the great longitudinal ones coincident either with the anticlinal and synclinal axis planes, or with the steep or inverted sides of the anticlinals. A distinctive character of these great fractures is their parallelism to

the axis planes, whether they are coincident with them or not. Many of the more extensive longitudinal dislocations of the Appalachians are traceable to the rupturing of the anticlinals along their most wrenched inverted slopes. These waves are entire at their extremities, but so broken along all their intervening portions as to present only one-half of the wave form, the other half being profoundly buried with inversion under the unbroken part. Generally, in these great dislocations, the gently-dipping uninverted slope of the waves has been shoved—in the inclined plane of the fault—forward and upward upon the other inverted and crushed half, and in some instances through a great distance.

The up-driven parts having been extensively removed by erosive action, the upper strata of the overturned buried half of the wave are seen to be immediately overlapped in nearly conformable altitude of dip by the denuded lower strata of the uninverted side. Similar phenomena of the plunging of newer formations under older ones, with approximately conformable dips, meet us continually in the Alps, and other much plicated districts, and can be demonstrated to have arisen from the same cause, the upward and forward propulsion of the uninverted halves upon the inverted sides of the anticlinal waves along the great sloping planes of dislocation, into which the flexures have snapped at the time of their sudden bending.

These several laws of crust undulations, consisting of those which relate to the parallelism, form, gradation in distance, shape, and dislocation of the waves, are exemplified in detail in the paper, and by appeals to the phenomena of some of the more conspicuously corrugated tracts of Europe. Viewing, as one such zone, the undulated districts of southern Belgium, the Rhenish Provinces, the Westphalian coal-field, the chain of the Ardennes, and the Hundsruck, Taurus, and Hartz ranges, and referring for proofs to the descriptions and maps of M. Dumont and other geologists, who have described these provinces in more or less detail, the author shows that this belt displays all the phenomena of structure and gradation described by him as so conspicuous in the Appalachians of America. Sections transverse to this region from S.E. to N.W. will be found to exhibit precisely the same succession, from closely folded flexures with metamorphism through steep normal waves, to broad, open, and approximately symmetrical ones.

The structure of the Jura chain of Switzerland likewise exhibits proofs of the same laws. There the crust waves closely resemble those of the Appalachians—the whole chain is composed of several groups of flexures, differing in their direction or strike; but the waves of each group display a remarkable parallelism among themselves. Very few of the flexures exhibit actual inversion of their steeper sides. It is remarkable that the steep slopes of the great waves of the Jura face the Alps; and those nearest the Alps, or on the borders of the valley of Switzerland, are more compressed than those on the far side of the chain,—their more inclined flanks, for example in the Weissenstein, dipping even perpendicularly, or a little past this, into partial inversion. This southward thrust of the crests of the Jura anticlinals would seem to imply a movement from the north, and not from the igneous axis of the Alps, or probably from both quarters, at the period of the production of the flexures.

The Alps themselves show the same general structural phenomena as the other plicated zones described, but under more complex conditions. This much convulsed mountain system contains but few waves of the open or normal type, consisting, except on its outer flanks, of many very close plications of the strata. When these foldings are carefully studied and structurally connected with each other, the whole chain appears to be composed of two or more central parallel igneous crests, and each flank of these mountain ranges of a belt of closely compressed waves. Each of these plicated zones or Alpine slopes displays the axis planes of its flexures dipping in towards the centre of its own chain, the flexures nearest the igneous axis plunging at a lower or flatter inclination than those more remote. High in the slopes of the chain, where denudation has removed the largest part of the originally present upper formations, only the synclinal folds of these remain preserved. These are the so-called V's of the tertiary and jurassic beds, pinched in between the closely folded anticlinals of the gneissic, and other older rocks. The inward dip of nearly all the beds of both slopes of the Alps, thus occasioned by the completeness of the folding and the outward thrusting of the anticlinal parts of the flexures, is the obvious cause of that fan-like feature of dip of the entire chain, which has recently excited so much discussion among geologists. Cleavage of the rocks, and a superinduced crystallization parallel to the cleavage

planes, contribute not a little, the author conceives, to the illusive appearance of a general inward dip of all the strata, even the newest, under the older formations of the high igneous crests of the chain; for both the cleavage planes and the crystalline foliation observe a very constant parallelism in the direction of their dip to the dip of the axis planes of the flexures.

Slaty Cleavage.

It is now a good many years since Professor Sedgwick and other geologists announced the important general fact, that the structure called *slaty cleavage* pervades the altered strata affected by it in directions independent of their bedding or laminæ of deposition; that these planes of cleavage are approximately parallel to each other over large spaces of country, however contorted the dip of the rocks; and that where the cleavage is well developed in a thick mass of slate rock, the strike of this cleavage is nearly coincident with the strike of the beds. Professor Phillips, in 1843, added to this rule a still more comprehensive and exact expression—that the cleavage planes of the slate rocks of North Wales were always parallel to the main direction of the great anticlinal axes. Since 1837, these phenomena of the close parallelism of the cleavage planes with each other, and with the main axes of elevation, have been observed and recorded by Professor W. B. Rogers and the author of this communication; and in 1849 the author submitted to the American Association for the Advancement of Science a communication on the analogy of the ribbon structure of glaciers to the slaty cleavage of rocks, in which he stated what he deems the true law of cleavage of a district of undulated and plicated strata,—namely, that the cleavage dip is parallel to the average dip of the anticlinal and synclinal axis planes, or those planes which bisect the flexures. The generality of this rule was shown by sections exhibiting the flexures and cleavage in the Appalachians, in the Alps, and in the Rhenish Provinces. Subsequent observations in other localities have confirmed the universality of this law; and the recent description of the Devonian strata in the south-west of Ireland by Professors Harkness and Blyth still farther tend to illustrate and establish it. In their paper in the *Edinburgh New Philosophical Journal* (October 1855), they not only recognise an agreement between the

strike of the cleavage planes and that of the several rolls (or anticlinals) which affect the island of Valentia, but they show, that while the cleavage dip is southerly, the anticlinal " curves have been pushed over in a more or less northerly direction," inverting the carboniferous limestones and coal measures. Their general statement is, that the cleavage structure of rocks does not result from the simple rolling of the strata, but from this cause, combined with a considerable amount of pressure, and this latter force acting from the south, has pushed over the strata in a series of oblique curves to the north, and given to the inclined cleavage more or less of its southern dip. They further support the deductions of Mr Sharp, " that there has been a compression in the mass in a direction everywhere perpendicular to the planes of cleavage, and an expansion of the mass along these planes in the direction of a line at right angles to the line of incidence of the planes of bedding and cleavage." But from this view of the mechanical nature and the direction of the force engendering cleavage the author of this communication begs leave to dissent.

A second general law is, that where the cleavage is fully developed, and the anticlinal and synclinal flexures are also conspicuous and very sharp, the cleavage planes immediately adjoining these bendings are not parallel to the axis planes, but radiate partially from them, in a fan-like arrangement, upward in the anticlinals, and downward in the synclinals. This aberration from the normal direction is, furthermore, not symmetrical upon the opposite sides of the geometric axis planes, but is usually greatest upon the inverted or steep sides of the waves.

A third prevailing relation of the cleavage planes is—their tendency to deviate from the normal direction of parallelism to the axis planes, in order to conform partially to the direction or dip of the strata; and as in every belt of uniform flexures closely plicated with inversions, the uninverted, or normal dips, greatly exceed the inverted ones in breadth, there prevails a lower inclination in the planes of cleavage than belongs to the planes bisecting the flexures.

There is yet another law modifying cleavage, dependent upon the mechanical texture, and possibly the chemical composition, of the strata. In formations composed of alternations of the coarser mechanical rocks, such as siliceous grits and conglomerates, with the finer-

grained argillaceous beds, such as slates, shales, or marls, the coarser beds are unaffected by cleavage, while the finer-grained ones are often pervaded by it. Indeed, there appears a strict proportion between the degree of intimate fissuring of the rocks by cleavage and the degree of comminution of the particles. Connected probably with this interruption in the propagation of the cleavage, the author has observed another modification of the cleavage planes,—namely, that they tend to curve a little from the normal direction, in the fine-grained argillaceous beds, approximating to parallelism with the surfaces of bedding of the adjoining coarser mechanical deposits, as they approach them, showing in a transverse section, a kind of gentle sigmoid flexure. This fact is well illustrated in the cleavage-traversed rocks at the base of the anthracite coal-formation of Pennsylvania, where the red shales alternate with the lower beds of the coal-sustaining conglomerates and coarse sandstones. These remarkable facts seem sufficient of themselves to refute the hypothesis, somewhat in favour at present, of the purely mechanical origin of the cleavage-producing force; for we cannot conceive how a mechanical force either of compression, or of tension, transmitted, as necessarily it must have been, very equally, through parallel layers of coarse and fine material, should have exerted no fissuring action the moment it reached the surface of the coarser beds, and yet have been able to cleave into thin parallel slaty laminæ the whole body of the finer-grained argillaceous strata. One would more naturally suppose that the less finely-aggregated softer mud rocks or shales would have been even less easily fissured into sharp cleavage joints than the more massive and better cemented grits.

Foliation.

The relations of the foliation or crystalline lamination of metamorphic strata to the cleavage planes and the planes of stratification, are next dwelt on. Two facts may be stated of foliation, which possess perhaps the constancy of general laws. One of them is, that this structure, as it is seen in gneiss and mica schist, observes, when the strata are not traversed by cleavage, an approximate parallelism with the original bedding. The author of this paper has beheld apparent exceptions to this rule in several localities near Philadelphia and elsewhere in the United States; and others have been noticed in Europe by Mr D. Sharpe and other good observers,

but all of them can be reconciled to the general fact, and reduced, it is conceived, to the one comprehensive law,—that the planes of foliation, or the laminæ formed by the crystalline constituents of the foliated rocks are parallel to the planes or waves of heat which have been transmitted through the strata. Whenever large tracts of the gneissic rocks retain a nearly horizontal undisturbed position, the foliation is almost invariably coincident with the stratification; and in this case the wave of heat producing the crystalline structure can only have flowed upwards through the crust, invading stratum after stratum in parallel horizontal planes. Again, when injections of granite have lifted the gneissic strata, the crystalline lamination is generally seen to be parallel to the plane of outflowing temperature.

The other general rule is, that the foliation is parallel, or approximately so, to the cleavage, wherever these two structures occur in the same mass of rocks. This fact, recorded by Darwin, of the gneissic rocks and clay slates of South America, has been noticed likewise by Mr D. Sharpe, Mr David Forbes, Mr Sorby, and other geologists in Great Britain, and by the author in many localities in Southern Pennsylvania. An interesting instance of such parallelism of the foliation to the cleavage, in the last-named region, tending to show convincingly that both phenomena are the consequences of one species of force, or but different degrees of development of the same molecular or crystallizing agency, is presented in the great synclinal trough of the lower Appalachian limestone, north of Philadelphia. On the north side of this trough, the primal and auroral rocks, Cambrian or Lower Silurian, dip S., over a wide outcrop, at a very regular angle of about 45°. On the south side, they have been lifted into, and even a little beyond, the perpendicular position, so that the synclinal axis plane of the belt dips at an angle of 65° or 70° to the south. Neither formation shows cleavage structure on the northern side of the valley, the limestone being there of an earthy texture, and in thick massive beds; but on the south, or upturned side, this limestone is altered into a mottled blue and white crystalline marble, and is pervaded with cleavage planes, dipping at angles of 70° and 80° southward. Many parts of the rock are like a foliated calcareous gneiss, thin laminæ of mica and talc dividing the slate-like plates of the marble. What is especially worthy of notice is, that the foliation of the mica and talc, composing some of the thin partings between the original

beds of the limestone, is itself very generally parallel to the cleavage in the adjoining calcareous rock. Indeed, wherever the cleavage is excessive, the mass throughout becomes, by introduction of fully developed talc and mica between its laminæ, a true foliated stratum. An especial interest attaches itself to cases of this kind, from their showing, in the two contrasted conditions of the absence and presence of metamorphism in the two opposite outcrops of the self-same synclinal stratum, that both effects, cleavage and foliation, have originated at the same time, and from one and the same cause, and are in truth but different stages of the same crystalline condition, superinduced on the mass by high temperature, at the period of its elevation.

The above enunciated general facts of the prevailing parallelism of the foliation to the cleavage, is but a corollary of the still more general relationship already expressed of the parallelism of the resultant planes of crystallization to the waves of heat, which have produced the metamorphism.

Theoretical Views.

Theory of the Flexion and Elevation of Undulated Strata.

The wave-like structure of the Appalachian and other undulated zones has been attributed by the author and his brother W. B. Rogers, in their communications to the American Association in 1842, and to the British Association in the same year, to an actual undulation of the supposed flexible crust of the earth exerted in parallel lines, and propagated in the manner of a horizontal pulsation, from the liquid interior of the globe. They have supposed the strata of such a region "to have been subjected to excessive upward tension, arising from the expansion of molten matter and gaseous vapour, and this tension relieved by parallel fissures formed in successive lines through which such elastic vapour escaped, the sudden removal of the pressure adjacent to the lines of fracture, producing violent pulsations on the surface of the liquid below. This oscillating movement would communicate a series of temporary flexures to the overlying crust, and these flexures would be rendered permanent (or keyed into the forms they present) by the intrusion of molten matter. If, during this oscillation, we conceive the whole heaving tract to have been shoved (or

floated) bodily forward in the direction of the advancing waves, the union of this tangential with the vertical movements may explain the peculiar steepening of the front side of each flexure, while a succession of similar operations will accomplish the folding under or inversion seen in the more compressed districts." They think that no purely vertical force, exerted either simultaneously or successively along parallel lines, could produce a series of symmetrical flexures, while a tangential pressure, unaccompanied by a vertical force, would result only in an imperceptible bulging of the whole region or in irregular plications, dependent on local inequalities in the amount of the resistance. The alternate upward and downward movement necessary to enable a tangential force to bend the strata into a series of regular parallel subsiding flexures was, they conceive, of the nature of a pulsation such as would arise from a succession of *actual waves* rolling in a given direction beneath the earth's crust. Successive feeble tangential movements could not agree either in direction or amplitude, nor is it easy to imagine how they could shift their positions through a series of parallel axis lines, nor how, when renewed, they could return always to the same lines to build up the conspicuous flexures. These oscillations of the crust, to which the undulated strata are attributed, have been, they conceive, of the nature of the earthquakes of the present day;—earthquakes being, as they have demonstrated, a true pulsation of the flexible crust of the globe, propagated in parallel low waves of great length and amplitude, with prodigious velocity, from lines of fracture, either conspicuous volcanic axes, or half-concealed deep-seated fissures in the outer envelope of the planet.

Theory of the Origin of Cleavage Structure.

Concerning the cause of slaty cleavage, the author of the paper has adopted the explanation originally proposed by Professor Sedgwick, that it is due "to crystalline or polar forces acting simultaneously and somewhat uniformly, in given directions, on large masses having a homogeneous composition." And following up the further suggestion in extension of this idea, ingeniously proposed by Sir John Herschel, that this molecular force was of the nature of an incipient crystallization, and has been developed in the particles by their being heated to a point at which they could begin to move among

themselves, or upon their own axes, he has endeavoured to show that, whether the cleavage-cut strata have been much disturbed or not, the cleavage planes invariably approximate to parallelism with those great planes in the crust, which give indications of having been the planes of maximum temperature. It has been already stated, in the present paper, that the cleavage dip is parallel to the average dip of the anticlinal and synclinal axis planes bisecting the flexures. Now it is easy to prove that these axis planes, and the inverted parts of the flexures, are just those portions where the greatest crushing, fissuring, and displacement of the strata must have occurred, and where the highly heated pent-up volcanic steam, gases, and liquid mineral matter would find their chief channels obliquely upward towards the surface. Not to attempt the application of this view in detail, it will suffice at present to state, that every plicated belt of strata may be regarded as having, at the time of its folding and metamorphism, contained from this cause a series of alternate hotter and colder planes or belts, arranged in parallel oblique dip. These planes of temperature are supposed to have acted to polarize the particles of the strata in corresponding parallel planes, by transmitting through the half-softened mass parallel waves of heat, stimulating the molecular crystalline forces ever resident in mineral matter in planes parallel to the generating surfaces.

3. On a Property of Numbers. By Balfour Stewart, Esq. Communicated by Professor Kelland.

4. Analysis of Craigleith Sandstone. By Thomas Bloxam, Esq., Assistant-Chemist, Industrial Museum, with a Preliminary Note by Professor George Wilson.

One object of the Laboratory of the Industrial Museum is the prosecution of investigations likely to throw light on the economic value of materials employed in the useful arts. It has been impossible this winter to do more than make a small beginning by instituting an examination into the properties of certain of our building stones; and as the results obtained in the case of the sandstone of Craigleith Quarry have an interest for geologists as well as for architects and builders, they are laid before the Society, as all similar results of any

scientific value will be in future. The entire investigation will be published in the course of the summer.

It is necessary to remark here that the following experiments were made solely upon the coarser variety of the stone, known as Common or Bed Rock; the finer portions, not yet submitted to chemical investigation, being called Liver Rock, most probably from the closeness of its grain.

The objects which I had chiefly in view in the course of the following inquiry were, the exact chemical composition of the stone; the extent to which it contains other insoluble substances than silica; the amount of substances soluble in pure water, in water saturated with carbonic acid, and in water containing the mineral acids. The extent to which the stone absorbs and retains water, was also object of investigation, and the coaly matter which occurs at intervals in it was analysed.

The whole of the analyses were made by Mr Thomas Bloxam, the assistant-chemist in the Laboratory of the Industrial Museum, who spent much pains on the inquiry. From what follows it will be seen that the Craigleith sandstone, as taken in cubes for building, is nearly all silica, but that it contains in addition small portions of alumina, lime, magnesia, iron, and, occasionally, a hitherto unsuspected ingredient, oxide of cobalt, which Mr Bloxam has distinctly indicated. In addition to those substances, black particles occur disseminated even through the whitest and most solid portions of the stone, which in the majority of cases appear to be coaly matter, but are sometimes in greater part carbonate of the protoxide of iron, coloured by an admixture of coal.

The condition in which those bodies occur in the stone is as important as their relative amount; but it is not so easily ascertained. Much of the silica is present in more or less perfect grains of quartz; a small portion occurs as the chief ingredient of scales of mica, and also probably as felspar; and according to Mr J. Napier of Partick, Glasgow, a certain amount of the silica is in combination with alumina as clay. Mr Napier experimented by reducing the stone to fine powder, and washing it on a flannel filter, which retained the silica, and allowed the clay to pass through. Proceeding in this manner, and receiving on a weighed filter paper the muddy water which passed through the flannel, Mr Bloxam found that 9·33 per cent. of substance remained on the paper after drying at 212°. This may pro-

visionally be called clay, of which it consists in small part; but till it is analysed, it would be premature to discuss its nature. Mr Napier's observation, however, that sandstones contain clay, is an important one, especially in reference to their power to retain moisture, and continue long damp in the walls of buildings.

The iron which occurs so generally in sandstones, and is so important an ingredient, from its tendency to stain the stone after it is quarried and exposed to the air, is certainly present in different chemical conditions. It has been generally assumed, I think, to occur in carboniferous sandstones as bisulphuret; but it appears to be chiefly present in the Craigleith rock as carbonate of the protoxide, the form in which it has always been recognised as prevailing in the shales accompanying such sandstones. As already mentioned, the protocarbonate of iron occurs in detached portions, coating and dividing certain strata of the stone from each other; but it is not on this circumstance that I found the conclusion stated above, but on the following results:—1000 grains of the stone, finely powdered, were suspended in cold distilled water, and a stream of washed carbonic acid gas sent through the liquid for an hour. The water passed through a filter quite transparent; but upon boiling became troubled, and deposited carbonates of lime and magnesia, peroxide of iron, and a little silica. Of these substances the peroxide of iron was the most abundant, and it had plainly been dissolved as protocarbonate. The probability, accordingly, is that the metal existed as carbonate in the sandstone; but it may have been present as metal or as black oxide, though scarcely as bisulphuret, and certainly not as peroxide. The point of most practical interest, however, is, that rain-water, containing, as it always does, carbonic acid, is able to dissolve iron as well as lime and magnesia from exposed sandstones; so that we may always expect to find them colour more or less from the solution and subsequent peroxidation of the iron which they contain.

It was not found possible to remove the whole of the iron from the powdered sandstone by the action of carbonic acid water, for after it had exerted its full effect, hydrochloric acid, if boiled on the powder, extracted iron as peroxide, unaccompanied by protoxide.

The action of other solvents on the stone is as follows:—Distilled water boiled upon it in fine powder acquired a notable quantity of lime, a small quantity of sulphuric acid, and a trace of iron. Minute quantities of the alkalies, of magnesia, and of silica were doubt-

less also present, but were not sought for. Hydrochloric acid boiled upon the powdered stone yielded a solution in which protoxide and peroxide of iron, alumina, lime, and magnesia, were found in marked quantity; and traces of manganese and cobalt, along with potassa, soda, and silica, in small quantities.

From those results it will be seen that the purest water can dissolve a certain amount of substance from Craigleith sandstone; that if charged with carbonic acid it will disintegrate it further; and that if containing free mineral acids, as the rain-water of towns occasionally does, it will decompose it still further.

In connection with those results, it is important to notice the extent to which the stone absorbs and retains water, points on which Mr Napier has already made valuable observations. The specimens selected for the following trials had an average sp. gr. of 2·443.

A piece weighing 3506·1 grains, which had been received from the quarry in the month of November 1855, and remained for about a month in a room without a fire, was kept at 212°, till it ceased to lose weight; the loss was equivalent to 5·7 fluid ounces per cubic foot.

A similar piece, weighing 4597·95 grains, was immersed in distilled water at 58°, till it ceased to gain weight. The surface-moisture was then allowed to evaporate, and the stone weighed. The gain was equivalent to 3·8 imperial pints per cubic foot.

According to Mr Napier, a sandstone acquires much more moisture if allowed to absorb it by capillary attraction from one part of its surface, than if entirely immersed in water, but upon making the experiment in the way he describes, the difference, by capillary attraction, was comparatively small; the whole gain being 4·2 imperial pints on the cubic foot. On the other hand, when the stone was immersed in water under the bell jar of the air-pump plate, and the air withdrawn, the ultimate gain in weight amounted to 6·2 imperial pints per cubic foot. The error of those who hope to render buildings dry by constructing their walls of solid sandstone, will be sufficiently apparent from these facts. The numerical results obtained by Mr Bloxam are added in full.

Analysis of Craigleith Stone.

Specific Gravity.	Action of Water on the Stone.	Action of Carbonic Acid Water upon the Stone.	Action of Hydrochloric Acid upon the Stone.	Loss on drying at 212° F.	Water absorbed by continued immersion.	Water absorbed by Capillary Attraction.	Water absorbed under the Air-Pump.
2·443	6 ounces water boiled on 305·70 grains of stone for 1 hour and 40 minutes, dissolved from it ·27 of a grain.	Dissolved Protoxide of Iron, Lime, and Magnesia.	Dissolved Protoxide of Iron, Peroxide of Iron, Oxide of Cobalt, Manganese, a trace, Alumina, Lime; Potassa and Soda, in small quantity.	5·7 Fluid ounces per cubic foot.	3·8 Imperial pints per cubic foot.	4·2 Imperial pints per cubic foot.	6·2 Imperial pints per cubic foot.

COMPOSITION IN 100 PARTS.

Silica,	96·95
Peroxide of Iron and Alumina,	2·30
Water,	·23
Lime, Magnesia, Oxide of Cobalt and Alkalies,	·52
	100·00

The following Gentleman was duly admitted an Ordinary Fellow:—

James Clerk Maxwell, Esq., Fellow of Trinity College, Cambridge.

The following Donations to the Library were announced:—

Report of the Yellow Fever Epidemic of British Guiana. By Daniel Blair, M.D. 8vo.—*From the Author.*

Physical and Geographical Map of India. By G. B. Greenough. 8vo.—*From the Executors of the late G. B. Greenough.*

Théorie de l'Antagonisme et de la Pondération. Par M. Alexandre Gérard. 8vo.—*From the Author.*

London University Calendar, 1856. 12mo.—*From the University.*

Proceedings of the Botanical Society of Edinburgh, 1855. 8vo.—*From the Society.*

The Quarterly Journal of the Geological Society. Vol. ii., part 4. 8vo.—*From the Society.*

Flora Batava. Afleverings 177 & 178. 4to.—*From the King of Holland.*

Abhandlungen, herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. 1ster Band, 2te, Lieferung. 4to.—*From the Society.*

Memorias de la Real Academia de de Ciencias de Madrid. Tome 1 and 2. 8vo.—*From the Academy.*

Positions moyennes pour l'époque de 1790,0 des étoiles circompolaires, dont les observations ont été publiées par Jérome Lalande dans les Mémoires de l'Académie de Paris de 1789 et 1790. Par Ivan Frederenko. 4to.—*From the Editor.*

Ueber Dr Wichmann's Bestimmung der Parallaxe des Argelanderschen Sterns. Von W. Döllen. 4to.—*From the Author.*

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nov. 1855—Avril 1856. 4to.—*From the Academy.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1856–57. No. 47.

Seventy-Fourth Session.

Monday, 24th November 1856.

Very Rev. Principal LEE, V.P., in the Chair.

The following Council were elected:—

President.

Sir T. MAKDOUGALL BRISBANE, Bt., G.C.B., G.C.H.

Vice-Presidents.

Sir D. Brewster, K.H.
Very Rev. Principal Lee.
Right Rev. Bishop Terrot.
Dr Christison.
Dr Alison.
Hon. Lord Murray.

General Secretary,—Professor Forbes.

Secretaries to the Ordinary Meetings,—Dr Gregory, Dr Balfour.

Treasurer,—John Russell, Esq.

Curator of Library and Museum,—Dr Douglas Maclagan.

Counsellors.

Hon. B. F. Primrose.
James Cunningham, Esq.
Dr Greville.
A. Keith Johnston, Esq.
Dr Maclagan.
Wm. Swan, Esq.
Dr Traill.
Hon. Lord Neaves.
Dr Thos. Anderson, Glasgow.
Rev. Dr. Hodson.
Robert Chambers, Esq.
J. T. Gibson-Craig, Esq.

Monday, 1*st December* 1856.

THE RIGHT REV. BISHOP TERROT, Vice-President, in the Chair.

Opening Address. By Bishop Terrot.

The Council of the Royal Society have, in the course of the last year, taken into serious consideration the state and prospects of the Society, and have deliberated upon many propositions having for their object to render our ordinary meetings more interesting, and generally to increase the efficiency and usefulness of the Society. Among other schemes of this nature, they have adopted one, in conformity with which I have now the honour of addressing you. They have resolved that henceforth the winter session shall commence with an Address from the President, or one of the Vice-Presidents, leaving it, of course, to the judgment of the individual selected to choose such topics as he may think most likely to excite, among the Fellows, a deeper interest in the welfare of the Society, a more earnest determination to render their scientific attainments, whatever they may be, serviceable, not merely to the world at large, and to the advancement of their own scientific reputation, but also to the efficiency and reputation of our common object of interest—the Royal Society of Edinburgh.

Possessing, as we do, a President equally distinguished for his science and for his love of science, for that which he has done himself, and for that which, by his open-handed liberality, he has invited and enabled others to do, it would have been most natural and desirable that he should have been requested to address you on this occasion. You are aware, however, that the state of his health is such as to render it very unadvisable that he should attend our evening meetings, and the Council were consequently under the necessity of laying this duty upon one of the Vice-Presidents. There also, you must be aware, the Council had but a small range of choice. Your senior Vice-President, to whom every one would have listened with interest and attention, and from whom even the most advanced in science might have learned something new, is, I regret to hear, obliged to retire to the Continent on account of the

health of a member of his family. Others on the list are prevented by various causes from attending our meetings; and the result has been that the Council felt itself under the necessity of imposing upon me the duty, which I now attempt to perform.

I think you will agree with me, that a Society like ours, instituted for a definite purpose—the advancement of Science and Literature—has, in relation to that purpose, a duty to perform; and that each member, according to the extent of his ability, is bound in duty to contribute to the energy and action whereby alone the Society, as a whole, can satisfactorily perform its obligations. Now, in relation to the purpose of the Society, the clear understanding of which must go far to determine the character of its duties, it cannot, I think, fail to strike you that for many years our attention has been exclusively directed to what is commonly called Science,—to the abstract, the physical, and the experimental sciences; while every thing coming under the designation of Literature is altogether absent from our proceedings. Literature, indeed, in its ordinary acceptation, is unsuited to our purpose. It is not desirable that, like the old French Academy, we should invite poets to recite fragments of some forthcoming epic, or historians to put us in advance of the external world, by communicating the *purpurei panni*, the heroic portraits, or battle-pieces, of a projected narrative. But I cannot see why the word Science should be restricted to the knowledge of material objects; why it should not be extended to all knowledge difficult to acquire, and relating to matters which are interesting to any considerable number of thinking, cultivated minds. It would surely be unjust to refuse the name of science to that philosophy which, in the hands of Smith, Reid, Stewart, and Brown, has done more to raise the character of Scotland as an intellectual nation, than all that she has done, and that is not little, in all the mathematical and physical sciences. And besides this science of mind, there exists a science of the great exponent of mind, of spoken or written language. This, in combination with anatomy, constitutes the science which the British Association have admitted into their cycle under the name of Ethnology. Even those among us who are most absorbed in abstract or physical science may feel some interest in learning to what extent, and how and why it is that a basis of sameness exists between the languages of a long line of nations extending from the Ganges to the Atlantic; how varieties of this one species

have branched off in different directions; how in some countries invading hordes have speedily obliterated the language of the conquered, while in others they have abandoned their own, and have adopted that of the conquered majority.

Now, I beg you to understand that I have no wish that either mental philosophy or philology should, in this Society, supersede those abstract and physical sciences with which we are generally occupied. All I would ask for is, that those who are engaged in the former should not be led to consider the Royal Society as an Institution in which they are not wanted, and in whose labours they can take no share. It may be replied, that there exists among us no exclusion of such students, and that our door is as open to them as to the Chemist or the Mathematician. There is no exclusion, but there is an obstruction. Such students, the speculators upon mind and language, when hesitating whether they shall propose themselves as candidates for admission into the Royal Society, will naturally look into some recent volume of our Transactions. There they will find little that can interest them—little that they can understand, or even read. For the notations employed by the analyst and the chemist are to them an unknown tongue; and though they be familiar with common arithmetic, they would not find a volume of the Makerstoun Observations very inviting. In short, the impression would be that our trade was not their trade, or that for their ware there was no demand in our market.

And yet this last conclusion would be a false one. There exists in the Society a very general wish for some infusion of literature into our proceedings, and it exists among those who are themselves most exclusively devoted to scientific pursuits. But it does not lie with the Anatomist, the Botanist, or the Astronomer, to supply the deficiency. All that they can do is to express not merely their willingness, but their wish, that men of letters would come forward and contribute something of a more general interest, and a more graceful character, to the severe simplicity of our usual evening engagements. About this time last year the Council issued a report to the Fellows, in which the subject to which I am now referring was urged very strongly. They then said, "It has long been a matter of regret that literary papers are so seldom offered; insomuch that it is often forgotten that the Royal Society was originally instituted for the interchange of literary as well as of scientific communications; in-

deed, that the Society long divided itself into two classes, having reference to those subjects. Essays on criticism, philology, and æsthetics, are to be found in the earlier volumes of the Transactions, but for many years such papers have rarely been communicated. The Council believe that such contributions would be very acceptable to the Society, even should the authors not in every case deem their observations sufficiently original and important to demand publication *in extenso* in the Transactions." Such was the urgent call made by the Council upon the literary members of the Society; but as yet the call has been made in vain.

I venture, in the next place, to offer a few words of counsel to those who are so far engaged in science as to be conscious that, by the withdrawal of a little time from their professional engagements, they might contribute either to the interest of our evening meetings, or to the contents of our annual publications. I distinguish between these two purposes, because I consider them widely separate. The ideal of a paper for the Transactions is, that it contains some new important truth; and since, by its publication, it is presented to the whole scientific world, it is clear that the author should have such knowledge not only of his branch of science, but also of its history, as may secure him from wasting his time upon the discovery of that which is already familiar to the masters of the craft. Such, I repeat, is the ideal of a paper for the Transactions. In many cases such a paper can give no gratification to the audience, and, indeed, in the very best cases such papers are not read throughout. A brief abstract of the purpose, method, and conclusion is all that is given; because the author is aware that, to a large portion of his hearers, the details would be uninteresting, because unintelligible; and that even those who are on a level with himself, require time fully and clearly to apprehend the accuracy of his arguments and of his calculations.

But no such requirements and limitations apply to communications made at our ordinary meetings, without any view to their being afterwards published in the Transactions. Those among us who are employed upon sciences of observation, and those who are watching the progress of science both at home or abroad, might add much to the interest of our meetings by communicating information which is not positively, but only relatively new; which might be found elsewhere, but which would probably not be found by many who would

gladly receive it, when presented to them by an intelligent informant. Nay, I do not see why the proposing of well-considered questions might not be considered relevant to the purpose of our evening meetings. Those who, from heavy professional occupations, cannot advance beyond the outskirts of any science, would be very troublesome members of society were they perpetually invading the studies of the learned, and applying for the solution of their doubts and difficulties. Yet such sciolists, among whom I must honestly class myself, have, in virtue of their fellowship, some claim upon the assistance of their more learned brethren; and that assistance might be easily afforded, if the proposing of a reasonable question, not pointedly addressed to any individual, were to be considered as an allowable and ordinary proceeding in our evening meetings. These suggestions may appear trifling or impracticable. My purpose will be served if only the attention of the more earnest working members of the Society be turned to the fact that the proceedings at our meetings possess little attraction for a great portion of the Fellows; and if they are led to devise some better plan for popularizing, without degrading, the public business of the Society.

I suppose, that if any of us were asked, What is the purpose of the Royal Society? he would answer generally, the promotion of science. But this formula, the promotion of science, may be taken in various senses. In one sense, and that the highest, a philosopher promotes science when he observes and publishes facts unknown before, or when he reduces known facts under the conditions of a new law. In either case he promotes science by increasing the number of things which may be known by study alone without invention. But the schoolmaster, in another sense, promotes science when he excites to the pursuit of science minds which, without such excitement, would have remained trifling or inert; when he smooths difficulties which would have discouraged, or altogether stopped, the progress of the young student; and in some, though certainly in a much lower degree, when he merely communicates to his pupils his own knowledge of the facts and laws of nature. The philosopher, in the successful exercise of his vocation, makes things knowable; the schoolmaster, in his vocation, makes them to be actually known. So far as I can see, these are the only two methods in which science can be directly promoted; and the question is, in which of these ways is it that our Society ought to labour for the promotion of science. Individual

members then, contribute to the advancement of science, when they communicate to the Society either the unrecorded facts which they have observed, or the results of their scientific experiments, or the general laws which they have established by processes of inductive reasoning, or improvements which they have effected in the instruments of observation, or in the calculus by which their reasonings are effected. The Society again, as a body, co-operates to this direct advancement of science, when, after winnowing the important from the unimportant, it gives to the world in its Transactions, such communications as, in its judgment, are fitted either to extend the field or to facilitate the acquirement of useful knowledge. But perhaps the indirect action of this and similar societies is more important than these its formal and visible products; nay, I know not whether the best answer to the question, What is the use of the Royal Society? would not be, that it is useful by bringing together, into familiar intercourse, men of science and men of letters—men of similar and of different views. Solitary study is requisite even for the most moderate attainment of knowledge; but a solitude unbroken by intercourse with other minds, is apt to generate, in scientific men, an overestimate of their own powers and performances, and a doting fondness for notions which are commonly described by the term crotchets. Now every man of vigorous and inquiring intelligence, and so far constitutionally qualified to become a man of science, who, by being brought into competition with his equals, and under the influence of his superiors, is induced to moderate his self estimation, and to abandon his crotchets, is thereby rendered a better, wiser, and more useful man than he was before. I need not again refer to the more obvious use of familiar intercourse among the professors and the lovers of science, of the labour and time that may be saved by the friendly communication of difficulties, or of the overcoming of difficulties, and by everything which tends in science to that generous, unselfish co-operation, which is the source of strength and progress in all artistic, commercial, and social life. Every great subject has some dark side; and, next to the unholy contests of intolerant religionists, I know nothing more melancholy than the disputes of men of science respecting priority of invention and discovery; to see them too evidently acknowledging, that not the discovery of truth, but the credit of having discovered it, is the stimulus and the reward to which they are looking.

The affording facilities for such intellectual intercourse between those who are engaged either upon the same or upon different branches of science, and the promotion of this generous, brotherly co-operation, is, I believe, in the present state of society, the most important purpose, and the most beneficial result of scientific institutions such as that which I have the honour of addressing.

The Council have, in the last year, acted as if they felt the force of some of these considerations. They have made the next apartment complete in everything that can conduce to the comfort of the Fellows who visit it, either for reading, writing, or consultation; and, situated as we are, at the very centre of our principal thoroughfare, they may, I think, be disappointed that so few of our members appear as yet to avail themselves of the accommodation afforded them. But they have taken a much more important step than this; they have devoted three hundred pounds, not from the capital, but from the savings of the Society, to the increase of the Library. Every department of science has been fairly represented in the sub-committee appointed to expend this sum; and if the Naturalists have carried off the lion's share in the distribution, this has arisen from no unfair preference, but from the great expensiveness of their necessary apparatus. A tolerably extensive library of mathematics or philology may be purchased at the price of a single publication on shells or ferns. In the geographical department our collection is eminently rich. We possess, and have mounted in a new and very serviceable manner, maps to the amount of 625 sheets. Of these 439 relate to Europe, and 78 to Asia; and many are from elaborate surveys, and on a large scale. The Council has also been busily employed during a great portion of the year in preparing a Catalogue of the Library. The completion of this has unavoidably been impeded by the gradual accession of additional books; but it is hoped that in the course of the present session, or of the succeeding summer, a complete and well-arranged Catalogue will be accessible to the Members of the Society; and that from it the students of every branch of science will learn that valuable contributions to their favourite branch, whatever it may be, have been recently made, with an especial view to the supply of works of reference, which were not to be found in the great public libraries of this city. It may not be uninteresting to the literary members to know that a considerable number of Dictionaries, Gram-

mars, and works on general Philology, are among the recent additions to the library.

Another important subject to which the attention of the Council has been directed, is the finance of the Society. Several circumstances have shown it to be desirable that the amount both of admission and annual payments should be diminished; and the statements drawn out by our very intelligent and zealous Treasurer, show that such diminution may be made without incapacitating the Society from carrying out any of its legitimate purposes. As the rate of fees is fixed by a law of the Society, the sanction of a general meeting will be necessary to the alteration; and a motion to that purpose will, I believe, be made this evening.

In recounting the duties of the Society, I ought to remind you that we are trustees of three funds devoted to the promotion of science; and are the judges appointed to select among competing candidates those most deserving of the prizes afforded from the interest of these funds. The first of these prizes is the Keith Gold Medal and Prize, given biennially to the author of that paper read before the Society which the Council considers as the most valuable contribution to science, made through the Society, during the two preceding sessions. The second is the Brisbane Prize, the special application of which was left by the learned and liberal donor entirely to the judgment of the Council. They have decided that this prize shall be awarded, at biennial periods alternating with the Keith Prize, and that for the first biennium it shall be awarded to the author of the best Biographical Memoir of some deceased Scotchman, distinguished by his scientific attainments. Thirdly, we have the Neill Bequest, which, in conformity with the well-known pursuits of the founder, will be devoted to the encouragement of natural history in its various branches. We are thus empowered to invite and stimulate and reward exertion—*1st*, In the great field of physical and experimental science; *2d*, In mathematics and astronomy; *3d*, In the investigation of the forms, properties, and relations of the various families of the organized creation. The destination of the Brisbane Prize appears to have this peculiar merit, that it gives scope for the exhibition of literary as well as of scientific merit; and I hope that those who may be induced to compete for it will remember that each of the heroes of science was not an abstract intellect, but a man, with human affections and passions acting for good or for evil—with moral

and religious tendencies, influencing, it may be, his scientific pursuits, and colouring his enunciation of his discoveries. Good biography, the accurate life-like portraiture of a great mind, is one of the highest achievements of literary skill.

Having thus directed your attention to some of the secondary offices and purposes of the Royal Society, I feel it right to revert to that which the external world will always consider as its primary duty, and by the adequate performance of which, without reference to anything else, the Society must rise or fall in the estimation of men of science at home and abroad; I mean, of course, the annual publication of a valuable fasciculus of Transactions. To this point the efforts of the leading members of the Society ought to be especially directed. Individually they may have scientific reputations to make: but they have not to create, but to maintain, the reputation of the Society. The papers contributed to our Transactions by Robison, Ivory, Hutton, Playfair, Hope, and Hall, will bear comparison with any on like subjects, and of the same date; while, to mention only one of our living members, the optical papers of Sir David Brewster have carried the name of the Royal Society of Edinburgh, in conjunction with his own, through the whole of the scientific world.

But though we may be obliged to confess that our more recent publications are inferior to those of an earlier date, this is not to be attributed entirely, if at all, to a falling off in industry or talent among our members. In the first place, there are ebbings and flowings in all intellectual pursuits; and I am told by those who know more of the matter than I do, that at present the tide of science is not flowing either here or elsewhere. Such turns of the tide in an advancing direction are, I think, generally attributable to the rise of some man of genius who gathers round him, and stimulates and directs the minds of those whose talents are of kin to his own genius. In this leading class we may place such men as Linnæus, Laplace, and our own Sir Humphry Davy; and I feel sure that Cambridge has lived and acted for a century and a half, not upon the reputation, but under the abiding influence of Newton and Bentley. If, then, science be at present but slowly progressive, it is, I suppose, because the men of talent, of whom there is no lack, are in want of a man of genius to lead them on.

Whatever may be thought of this, there exist causes which ren-

der the preparation of a good volume of Transactions more difficult in the present day than at any former period; and these difficulties are not peculiar to our Society, but are felt, I believe, by all similar institutions. The first of these is the multiplication of scientific societies, each devoted to some particular branch—Chemical, Astronomical, Geological, and Botanical. Whether science is more effectively promoted by such specific associations, or by those which, like our own, give a general admission to contributions in every branch of science, I do not take upon me to say. The practice of all the civilized nations in maintaining, under some designation or other, an academy of science, and giving to it a pre-eminence above societies working in a limited field, shows I think a general feeling that the necessity for the former is not superseded by the multiplication of the latter. And there are reasonable grounds for this feeling. The dictum of the orator in accounting for his interest in the poet is so universally admitted as almost to have passed into a proverb: "Etenim omnes artes quæ ad humanitatem pertinent, habent quoddam commune vinculum, et quasi cognatione quadam inter se continentur." To strengthen this vinculum and relationship is not the least important office of the Royal Society: and therefore whatever attraction our members may find in societies instituted for the exclusive promotion of their own favourite pursuits, they will, I trust, never abandon their allegiance to science in the largest acceptation of the term, nor their co-operation with that society which gives a cordial reception to every art, *uæ ad humanitatem pertinet.*

Still I fear that such specific societies, whether publishing their own transactions, or sending them to the various specific journals, must draw away many valuable papers, which at an earlier period would have found no convenient channel of publication but in the pages of our Transactions. This turning of our supplies into other channels it is impossible for us to prevent; and so that science is promoted, we ought not to care very deeply whether this is done through us or through others. But a generous emulation is something very different from an envious rivalry; and the activity and success of other scientific societies ought to stimulate those of our brethren who have already proved their competence, to continued and increased exertions to promote the usefulness and the reputation of the Society.

And now I must refer to a subject, which, indeed, if we be a So-

ciety actuated by a really social spirit, must be more or less in the minds of the Fellows, when we meet for the first time after the interval of the summer vacation. The interval is not long, and yet it has been sufficient to produce great changes in the managing portion of the Society, by the removal from this world of several of those who united high scientific attainments with a deep interest and careful attention to the ordinary business of the Society. The members removed by death during the last year are Sir George Ballingall, Professor Gray, Colonel Madden, Mr John Clerk Maxwell, General Martin White, and Mr James Wilson.

It might be thought invidious for the Society acting in its corporate capacity to single out among these some whose memory deserved commemoration above that of others. But an individual can speak of that only which he himself knows, and must be allowed to speak in preference of those whom he knew, not merely by the reputation of their talents, but more closely in the intercourse of professional or of social life.

I mention then, in the first place, Sir George Ballingall, who closed a life of much useful activity at the advanced age of seventy. His scientific labours, so far as I am informed, were very much limited to his profession; his more important works, such as his Lectures on "Military Surgery," "On the Construction of Hospitals," "On the Diseases of India," were all intended to communicate to the younger members of the medical profession the results of his own long and careful experience as an army surgeon and as a medical officer in India; and his more numerous occasional papers, having all the same professional character and purpose, appeared, not in our Transactions, but in the journals of Medical Science. Throughout his long career in the army, in the University of Edinburgh, and in private practice, Sir George possessed the confidence and esteem of all with whom he was connected, and this was due not only to his professional knowledge and skill, but also to his upright and gentlemanly deportment in private life.

I have next to speak of one whose name and person at least have been more under the notice of the younger Fellows of the Society, from the circumstance of his having very kindly and very effectively undertaken the duties of General Secretary, when for a time we were under great difficulty from the severe and protracted illness of Professor Forbes. I should not have ventured upon any attempt to

delineate, even in outline, the moral and scientific character of Mr James Wilson, had I not felt that whatever might be thought or said of him elsewhere, something was due to his memory in this place and at this time. I should not have attempted it, because the branches of science which he cultivated have never occupied my attention, and because the whole of his character, both in its moral and intellectual aspects, has already been depicted by our brother Professor George Wilson, who knew his honoured namesake more intimately than I did, and who is far better qualified than I am to speak of his scientific labours. Indeed, I must confess that, whatever, in the execution of the office assigned me, I feel bound to say respecting our excellent and lamented brother, James Wilson, is either borrowed from or confirmed by the beautiful Memoir of him which has appeared in the Edinburgh New Philosophical Journal, from the pen of Dr George Wilson—not a kinsman, I believe, but certainly a man of kindred spirit with the subject of his Memoir.

A weakness of constitution, which manifested itself in his early manhood, withdrew Mr Wilson from the labours of a profession; and as his leisure permitted, so his inclination prompted him to devote himself to the study of animated nature. His retiring modesty could not prevent his becoming known as an accomplished naturalist; "and after the death of the late Professor Edward Forbes, the Chair of Natural History in the University of Edinburgh was offered to, but declined by, Mr Wilson. He was an acknowledged authority on Entomology, and scarcely less distinguished as an Ornithologist and Ichthyologist." His published contributions to science, generally anonymous, were extensive and important. To the seventh edition of *The Encyclopædia Britannica* alone he furnished a whole volume of articles, amounting to 649 pages, all on subjects of Natural History. He contributed largely to the various scientific journals, and to the transactions of scientific societies, while at the same time his literary talent and genial humour were shown by many interesting papers which appeared in the more popular Magazines and Reviews of his time.

But Mr Wilson has a higher claim on our affectionate remembrance than could be founded upon his scientific labours alone. He was a good man of a high type of goodness. The gentleness of his temper must have been apparent to all who had any intercourse with

him in the business of this Society; but those who knew him most intimately concur in testifying that his naturally amiable mind was indebted for much of its charm to the pervading influence of a deep religious principle; that he sought after God, not in his works only, but in his word also; and that he closed his blameless and useful life by a death robbed of its sting, and left this world with a humble reliance upon the promise of better things to come.

We have lost another and very kindred spirit by the death of Colonel Edward Madden. Him I knew intimately, and though his favourite track of science was very remote from my pursuits, I soon learned that his mind had many sides and could not fail to interest any one who had a respect for talent or a love for goodness. Colonel Madden joined our Society in 1853, and not having, as far as I know, read any papers at our meetings, he was probably little known to a large portion of the Fellows. But his character and attainments were well known to botanists, and they gave a sufficient proof of the estimation in which they held him by electing him to the Presidency of the Botanical Society. He was, soon after his admission as a Fellow, elected into the Council of this Society, and rendered valuable assistance as a member of the Library Committee, from his extensive knowledge, not of his own science only, but also of the apparatus required by the student of geography and of philology.

I have to express my gratitude to Dr Falconer of London for having supplied me with notices respecting Colonel Madden's pursuit of Science in India, much beyond what I can use on the present occasion, and which I shall return to him, in the hope that he may employ them in raising a worthy memorial of our departed friend.

From these notices it appears that before Colonel Madden's attention had been directed to the vegetable kingdom, and when he was a lieutenant of artillery in the Company's service, he employed a leave of absence in search of health among the lower ridges of the Himalaya. Health he found; but he found something more,—his own proper vocation as a lover and a student of nature. In no other region, probably, could his natural powers and tendencies have been so strongly called into action. No region presents the leading phenomena of physical geography in greater contrast, both as regards

the varieties of human races, difference of vegetable and animal life, meteorological and other climatic conditions, than the north-western plains of India, and the stupendous chain of mountains by which they are bounded on the north. Here, in comparative proximity, are found the vegetable productions of the Torrid and the Temperate Zones, while the traveller, as he ascends through a belt of Alpine character, reaches at length the region of perpetual snow.

When Lieutenant Madden first visited these interesting regions, he appears to have been totally unacquainted with systematic botany. But he brought with him a vivid recollection of the vegetable forms which he had noticed at home, and a tendency and capacity for observing every affinity or contrast to these in the objects which surrounded him in India. These observations were regularly noted down; and though necessarily very imperfect, they were of material service to him when afterwards he prepared and published his memoirs "On the Plants of the Turaee," and "On the Coniferæ of the Himalaya."

A few years after this tour, Colonel Madden revisited the Himalaya, and was there fortunate in making the acquaintance of Dr Falconer, at that time Superintendent of the Botanic Garden at Saharunpore, a station very near the foot of the Himalaya. It was here that his mind was formed to the systematic study of his favourite science. Here he had access to a rich collection of plants, to a well-stored herbarium, to a good botanical library, and to the society of experienced and friendly instructors. Of these advantages he made the most; and the fruits of his studies were shown in his first publication of any importance, entitled, "Brief Observations on Himalayan Coniferæ." This was first published in an obscure local journal, but reprinted in the "Journal of the Agricultural Society of Calcutta," and through that channel found its way into general notice among the botanists of Europe. A supplement to this paper, more extensive than it, was printed in the latter journal in 1850, after the author had left India. These memoirs are of such striking merit that they were transferred *in extenso* by Dr Lindley into the Journal of the Horticultural Society of London.

Soon after leaving Saharunpore, Colonel Madden was removed to a station in the hill province of Kumaoon. He was there fortunately brought into co-operation with the two brothers, Captains

Henry and Richard Strachey, at that time employed upon an inquiry into the physical geography of that and the adjoining Hill Provinces. The results of the labours of the Stracheys are well known, through memoirs communicated to the Royal Geographical and Geological Societies. Colonel Madden was an active colleague to Captain Richard Strachey in the botanical branch of this survey; and in 1848 he published the results of his observations in a very valuable memoir on "The Turaee and outer mountains of Kumaoon," which appeared in the Journal of the Asiatic Society of Bengal. These are spoken of by Dr Falconer as models of careful observation on the geographical distribution of plants, and at the same time as rich in illustrations, drawn from every department of a well-stored mind, and a wide and varied range of literature.

Hitherto, I have been speaking of Colonel Madden from the notes of his attached friend Dr Falconer, and in reference to scientific attainments and labours on which, you are all aware, that I am incompetent to form, and *à fortiori*, to express an opinion. All of you who knew him in social life, or in the Council meetings of the Royal Society, must remember with affectionate regret the gentleness of his manner, and the unobtrusive modesty with which he gave his assistance only when it was needed, and where he was sure of the precision of his knowledge. In respect to the highest wisdom, it appears that from his youth he was actuated by that love of the true and the good which constitutes the character of those who, if not actually in, are at any rate not far from the kingdom of Heaven. Careful and conscientious inquiry led him from doubt to conviction; and his latter years were spent under the influence of an assured faith and a steady resolution to do the will of God.

Such were some of those who have been taken from among us in the course of the last year, and whose virtues and useful labours will not be forgotten by those with whom they co-operated for the advancement of science.

I must now conclude my very imperfect performance of the task imposed upon me by the Council, with the expression of a hope that, on future occasions of the same kind, they may be more fortunate in their choice, and obtain addresses more worthy of occupying the time and attention of the Society.

C. H. T.

The following statement as to the Members of the Society was read by the Chairman:—

Ordinary Fellows at November 1855,		267
Add one name omitted by mistake,		1
		268
Deduct deceased—Sir G. Ballingall, Professor Gray, Colonel Madden, Mr John Clerk Maxwell, Dr Wilson Philip,* General Martin White, Mr James Wilson,		7
		261
Resigned—Mr Forbes of Culloden, Mr Grant of Elchies,	2	
Struck off for non-payment of Admission Fees—Mr E. Bonar,	1	
		3
		258
But add new Fellows—Dr Allman, Mr Bryce, Mr Cleghorn, Mr Mitchell Ellis, Mr James Hay, Dr Laycock, Professor Clerk Maxwell, Lord Neaves, Dr Penny, Mr R. M. Smith,		10
		268

The following Communication was read:—

On the Minute Structure of the Involuntary Muscular Tissue. By Joseph Lister, Esq., F.R.C.S. Eng. and Edin. Communicated by Dr Christison.

In this paper the author, after a short general account of the different forms in which contractile tissue occurs in the human body, describes at greater length the discovery made in 1847 by Professor Kölliker, that involuntary muscular fibre is capable of being resolved into nucleated elements, supposed to be of the nature of elongated cells, and hence termed "contractile" or "muscular fibre-cells." He then alludes to some authorities who object to this view of the structure of involuntary muscle, and notices, especially, a paper by Professor Ellis of University College, London, read before the Royal Society of London in June of the present year (1856), in which that distinguished anatomist expresses his belief that "the fibres are long, slender, rounded cords of uniform width," and that the nuclei "appear to belong to the sheath of the fibre;" whence it is to be inferred that Kölliker's fibre-cells are, in the opinion of Mr Ellis, created by the tearing of the tissue in the preparation of the objects.

* Dr Philip has been for some years dead.

The author then proceeds to describe the involuntary muscular tissue as it presents itself in two situations where he has recently examined it, namely, the minute arteries of the frog's foot and the small intestine of the pig. He finds that, by suitable manipulation, exceedingly delicate arteries may be dissected out from the web of the frog, some of them being of smaller calibre than average capillaries; and that in such vessels the middle coat consists of neither more nor less than a single layer of Kölliker's muscular fibre-cells wrapped spirally round the internal membrane, and of sufficient length to encircle it from about one and a half to two and a half times. The tubular form of the vessels enables the observer, by proper adjustment of the focus, to see the fibre-cells in section; and where the nucleus is so placed in the artery as to appear in section also, the section of the nucleus is invariably found surrounded on all sides by that of the fibre-cell, whence it is inferred that the nucleus is not merely connected with the external part of the muscular element, but is embedded in its substance. Considering that no tearing of the tissue is practised in the preparation of the objects, but that the parts are seen undisturbed in their natural relations, this simple observation appears to prove conclusively, that, in the arteries of the frog's foot, the involuntary muscular tissue is constituted as Kölliker has described it.

The pig's intestine proved to be a very favourable situation for the investigation of unstriped muscle, the fibre-cells being larger than in the human subject in the same situation, and very readily isolated by simply teasing out a small portion of the tissue with needles in a drop of water. Under these circumstances, they corresponded exactly with Kölliker's descriptions, and the delicate and perfect form of their tapering extremities was sometimes seen to be such as could not possibly have been produced by the tearing of a continuous fibre. In one fibre-cell that happened to be coiled up, the position of the nucleus embedded in its substance was seen in the same way as in the arteries of the frog. In examining the circular coat of a contracted piece of intestine from a freshly killed pig, the author observed some short, substantial-looking bodies of high refractive power, each of a somewhat oval shape, with more or less pointed extremities, and presenting several strongly-marked, thick, transverse ridges upon its surface; and each, without excep-

tion, possessing a roundish nucleus, whose longer diameter lay across that of the containing mass. Between these bodies and the long and delicate fibre-cells every possible gradation could be traced, and it was therefore pretty clear that the former were but the extremely contracted form of the latter. That the appearances in question were due to contraction of the fibre-cells, was proved by their disappearance when a portion of the tissue was strongly stretched.

The bearings of these observations on the main question, respecting the structure of involuntary muscular fibre, are obvious and important. In the first place, if the short substantial bodies were mere contracted fragments of rounded fibres of uniform width, we should expect them to be as thick at their extremities as at the middle; instead of which they are always more or less tapering, and often present a very regular appearance of two cones applied to each other by their bases.

Secondly, the uniform central position of the nuclei in the contracted fibres, proves clearly that the former are no accidental appendages of the latter, to which it seems difficult to refuse Kölliker's appellation of *cells*.

In conclusion, the author makes the following remarks:—

To sum up the general results to which we are led by the facts above mentioned, it appears that in the arteries of the frog, and in the intestine of the pig, the involuntary muscular tissue is composed of slightly flattened, elongated elements, with tapering extremities, each provided at its central and thickest part with a single cylindrical nucleus imbedded in its substance.

Professor Kölliker's account of the tissue being thus completely confirmed in these two instances, and the description here given of its appearance in the arteries of the frog's foot being an independent confirmation of the general doctrine, there seems no reason any longer to doubt its truth.

It further appears, from what has been seen in the pig's intestine, that the muscular elements are, on the one hand, capable of an extraordinary degree of extension, and, on the other hand, are endowed with a marvellous faculty of contraction, by which they may be reduced from the condition of very long fibres to that of almost globular masses. In the extended state they have a soft, delicate, and,

usually, homogeneous aspect, which becomes altered during contraction by the supervention of highly refracting transverse ribs, which grow thicker and more approximated as the process advances. Meanwhile the "rod-shaped" nucleus appears to be pinched up by the contracting fibre, till it assumes a slightly oval form, with the longer diameter transversely placed.

The author further remarks, that these properties of the constituent elements of involuntary muscular fibre explain in a very beautiful manner the extraordinary range of contractility which characterises the hollow viscera.

The following Donations to the Library were announced:—

Collection of Charts, published at the Hydrographic Office, London, with relative Descriptions.—*From the Admiralty.*

Results of Meteorological Observations, made at Sundry Academies in the State of New York, from 1826 to 1850 inclusive. Compiled by F. B. Hough, M.D. 4to.—*From the State of New York.*

List of Members and Report of Council, &c., of the Royal Institute of British Architects, 1856. 4to.—*From the Institute.*

Annual Report of the Trustees of the New York State Library, 1856. 8vo. *From the State of New York.*

List of Foreign Correspondents of the Smithsonian Institution, 1856. 8vo.—*From the Institution.*

Map of Boundary between the United States and Mexico. By W. H. Emory, U.S. Commissioner.—*From the Smithsonian Institution.*

Smithsonian Contributions to Knowledge. Vol. VIII. 4to.—*From the Institution.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vol. XXV., Pars 2. 4to.—*From the Academy.*

Mean Zenith Distances. Collection of all the Results of Observation of each star at Heerelogements-Berg, and Deduction of Mean Zenith Distance, 1843. January 0.—*From the Royal Observatory, Cape of Good Hope.*

Memoirs of the Royal Astronomical Society. Vol. XXIV. 4to.—*From the Society.*

Astronomical and Magnetical, and Meteorological Observations made

at the Royal Observatory, Greenwich, in the year 1854. 4to. —*From the Royal Society.*

Magnetical and Meteorological Observations, made at the Hon. East India Company's Observatory, Bombay, in the years 1852-53. 2 Vols. 4to.—*From the Hon. E. I. Company.*

Memoirs of the American Academy of Arts and Sciences. New Series. Vol. V., Part 2.—*From the Academy.*

Proceedings of the American Association for the Advancement of Science. Sessions 1853, 1854, and 1855.—*From the Association.*

Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. VII., Nos. 8-12; and Vol. VIII., Nos. 1 and 2.—*From the Academy.*

Annales de l'Observatoire Physique Central de Russie. Ann. 1851, 1852, 1853. 3 Tom. 4to.—*From the Observatory.*

Comte-Rendu Annuel, Supplement aux Annales de l'Observatoire Physique Central, pour l'année 1853. (2 copies.)—*From the Observatory.*

Correspondance Météorologique. Publication trimestrielle de l'Administration des Mines de Russie, pour ann. 1853, 1854. 2 Tom. 4to.—*From the same.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe. Bande X., XI. 4to. (2 copies.)—*From the Academy.*

Beschreibung und Lage der Universitäts-Sternwarte in Christiania, von Christopher Hansteen. 4to.—*From the Observatory.*

Ofversigt af Finska Vetenskaps-Societetens Forhandlingar, 1838-53. 4to.—*From the Society.*

Observations faites à l'Observatoire Magnétique et Météorologique de Helsingfors, sous la direction de Jean Jacques Nervander. Vol. I., II., III., et IV. 4to.—*From the Observatory.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. Deel. III. 4to.—*From the Academy.*

Oversigt over det danske Videnskabernes Selskabs Forhandlinger i Aaret, 1855.—*From the Society.*

Videnskabernes Selskabs Skrifter. 5te Række. Naturvidenskabelig og Mathematisk Afdeling. 4de Binds, 1ste Hefte. —*From the same.*

Observationes Meteorologicæ per annos 1832-54 in Grönland factæ. —*From the same.*

Flora Batava. Part 179. 4to.—*From the King of Holland.*

Memoire della Accademia delle Scienze dell' Instituto di Bologna. Tom. VI. 4to.—*From the Academy.*

Rendiconto delle Sessioni 1854-55, dell' Accademia delle Scienze dell' Instituto di Bologna. 8vo.—*From the same.*

Indices Generales in Novos Commentarios Academiæ Scientiarum instituti Bononiensis. 4to.—*From the Academy.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tom. XIV., Part 1. 4to.—*From the Society.*

Rapport sur les Travaux de la Société Impériale Zoologique, Paris. Par Aug. Duméril. 8vo.—*From the Author.*

Ichthyologie Analytique ou Essai d'une Classification Naturelle des Poissons. Par A. M. C. Duméril. 4to.—*From the Author.*

Abhandlungen der Koeniglich Bayerischen Akademie der Wissenschaften. Historischen Classe, Vol. VII., Part 3, Vol. VIII., Part 1. Philosoph.-Philologischen Classe, Vol. VII. Part 3. Mathemat.-Physikalischen Classe, Vol. VII., Part 3. 4to.—*From the Academy.*

Gelehrte Anzeigen, herausgegeben von Mitgliedern der K. bayer Akademie der Wissenschaften. Vols. XL., XLI. 4to.—*From the Academy.*

Archives du Muséum d'Histoire Naturelle. Tom. VIII., livraisons 3, 4. 4to.—*From the Museum.*

Monatsbericht der Koniglichen Preuss. Akademie der Wissenschaften zu Berlin, January—June 1855. 8vo.—*From the Academy.*

Observations Météorologiques faites a Nijne-Taguilsk (Monts Oural), Gouvernement de Perm. Année 1854. 8vo.—*From the Russian Observatory.*

Bulletin de la Société Vandoise des Sciences Naturelles. Nos. 34-37. 8vo.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. Vol. VI., Nos. 2–4 ; Vol. VII., No. 1. 8vo.—*From the Institute.*

Abhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt. Vol. III., 4to.—*From the same.*

Memoire della Reale Accademia delle Scienze di Torino. 2d Ser. Vol. XV. 4to.—*From the Academy.*

Jahrbücher der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Von Karl Kreil. Vol. IV. 4to. (2 copies.) —*From the Imperial Academy of Sciences, Vienna.*

Abhandlungen der Akademie der Wissenschaften zu Berlin 1854. 4to.—*From the Academy.*

Portrait of Carl Haidinger.—*From his son, W. Haidinger.*

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XVI., Part 2. 8vo.—*From the Society.*

Publications of the Dépôt Général de la Marine :—

Collection of Charts.

Pilote de la Mer Baltique. 8vo.

Portulan des Cotes de la Manche. 8vo.

Le Pilote Danois. 8vo.

Renseignements Hydrographiques sur la Mer d'Azof. 8vo.

Description du Golfe de Finlande et de l'entrée du Golfe de Bothnie. 8vo.

Observations Chronometriques faites pendant la Campagne de Circumnavigation de la Corvette La Capricieuse. 8vo.

Manuel de la Navigation dans la Mer Adriatique. 8vo.

Exposé du Régime des Courants Observés dans la Manche et la Mer d'Allemagne. 8vo.

Description des Cotes de l'Esthonie, de la Livonie, de la Courland (Russie), de la Prusse, et de la Pomeraine, jusqu'au Cap Darserort. 8vo.

Routier de l'Australie Traduit de l'Anglais, &c. 8vo.

Annales Hydrographiques, Recueil d'Avis, Instructions, Documents, et Mémoires relatifs a l'Hydrographie et a la Navigation. 8vo.

Catalogue Chronologique des Cartes, Plans, Vues de Côtes Mémoires, Instructions Natiques, &c., qui composent l'Hydrographie Française. 8vo.

Annuaire des Marées des Côtes de France, pour l'an 1855. 16mo.—*From the Dépôt Général de la Marine.*

Vierzehn Kupfertafeln zu H. B. Geinitz Darstellung der Flora des Hainichen—Ebersdorfer und des Flöhaer Kohlenbassins.—*From the Author.*

Descriptive and Illustrated Catalogue of the Histological Series

contained in the Museum of the Royal College of Surgeons of England. Vol. I., Elementary Tissues of Vegetables and Animals. 4to.—*From the Council of the College.*

A Monograph on Recent and Fossil Crinoidea, with Figures and Descriptions of some Recent and Fossil allied Genera. By Thomas Austin, F.G.S. Nos. 1–8. 4to.—*From the Author.*

Medico-Chirurgical Transactions, published by the Royal Medical and Chirurgical Society of London. Vol. XXXIX.—*From the Society.*

Report of the U.S. Commissioner of Patents for the year 1854. Agriculture, Arts, and Manufactures. Vol. II. 8vo.—*From the Commissioner.*

Memoirs of the Literary and Philosophical Society of Manchester. Second Series, Vol. XIII. 8vo.—*From the Society.*

Proceedings of the Zoological Society of London. Part XX., Nos. 258, 259; Parts XXI.; XXII.; and Part XXIII., Nos. 301–319. 8vo.—*From the Society.*

The Assurance Magazine and Journal of the Institute of Actuaries, Nos. 25 and 26. 8vo.—*From the Editor.*

Proceedings of the American Philosophical Society, 1855. Nos. 53 and 54. 8vo.—*From the Society.*

Proceedings of the Boston Society of Natural History, May—December 1855, and January—April 1856. 8vo.—*From the Society.*

Annals of the Minnesota Historical Society, 1856; containing Materials for the History of Minnesota, prepared by E. D. Neill, Secretary. 8vo.—*From the Society.*

Journal of the Royal Dublin Society. No. 1. 8vo.—*From the Society.*

Transactions of the Pathological Society of London. Vol. VII. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Nos. 77–81 (New Series). 8vo.—*From the Society.*

Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the year 1854. Vol. XV. 8vo. —*From the Radcliffe Trustees.*

Medical Topography of Brazil and Uruguay, with Incidental Remarks. By G. R. B. Horner, M.D. 8vo.—*From the Author.*

Description of a New Mollusk, from the Red Sandstone near Pottsville, Pa. By Isaac Lea.—*From the Author.*

Meteorology and Climate of Shanghae; deduced from Observations made during the years 1848–53. By John Ivor Murray, M.D., F.R.C.S.E.—*From the Author.*

The Canadian Journal of Industry, Science, and Art. New Series, Nos. 3 and 5, 8vo.—*From the Canadian Institute.*

Om Dodeligheden i Norge. Af Gilert Sundt. 12mo.—*From the Author.*

The Natural History of Deeside and Braemar. By the late William Macgillivray, LL.D. Edited by Edwin Lankester, M.D. 8vo. —*From H.R.H. Prince Albert.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Second Series. Nos. 62–64. 8vo.—*From the Editors.*

Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. VI., Nos. 7–12. Vol. VII., No. 1. 8vo.—*From the Academy.*

Report on the Geology of Northern and Southern California. By Dr John B. Trask. 8vo.—*From the State of California.*

The Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. New Series, Nos. 50–53. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. IX., Parts 2 and 3. 8vo.—*From the Society.*

The Quarterly Journal of the Geological Society. Vol. XII. Parts 2, 3, and 4. 8vo.—*From the Society.*

Transactions of the Historic Society of Lancashire and Cheshire. Vol. VIII. 8vo.—*From the Society.*

Laws of the Historic Society of Lancashire and Cheshire.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. VII., Parts 1, 2, and 3. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society of London. Nos. 1, 2, 3, 4, and 5. 8vo.—*From the Society.*

Journal of the Royal Geographical Society. Vol. XXV. 8vo.—*From the Society.*

An Account of the Construction of the Britannia and Conway Tubular Bridges. By William Fairbairn, C.E. 8vo.—*From the Author.*

On the Application of Cast and Wrought Iron to Building Purposes. By William Fairbairn, C.E. 8vo.—*From the Author.*

Useful Information for Engineers; being a Series of Lectures delivered to the Working Engineers of Yorkshire and Lancashire. By William Fairbairn, F.R.S. 8vo.—*From the Author.*

Journal of the Ethnological Society of London. Vol. IV. 8vo. —*From the Society.*

Regulations of the Ethnological Society of London. 8vo.—*From the Society.*

A Treatise on Electricity in Theory and Practice. By Aug. de la Rive. Translated for the Author by Charles V. Walker, F.R.S. Vol. II. 8vo.—*From the Author.*

Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, 1855. 8vo.—*From the Society.*

The Twenty-Third Annual Report of the Royal Cornwall Polytechnic Society, 1855. 8vo.—*From the Society.*

Notices of the Meetings of the Members of the Royal Institution of Great Britain. Part VI. 8vo.—*From the Institution.*

Proceedings of the Yorkshire Philosophical Society. Vol. I. 8vo.—*From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool, during the Forty-fifth Session, 1855-56. No. X.—*From the Society.*

Monthly Notices of the Royal Astronomical Society, containing Papers, Abstracts of Papers, and Reports of Proceedings of the Society. Vols. XV. and XVI. Nos. 6—9. 8vo.—*From the Society.*

The Quarterly Journal of the Chemical Society. Nos. 33—35. 8vo.—*From the Society.*

Proceedings of the Royal Society. Vol. VIII., Nos. 21, 22. 8vo.—*From the Society.*

List of Fellows of the Royal Astronomical Society, February 1856. 8vo.—*From the Society.*

On the Tree Producing Red Cinchona Bark. By John Eliot Howard. 8vo.—*From the Author.*

Papers read at the Royal Institute of British Architects, 1856. 4to. —*From the Society.*

Journal of the Proceedings of the Linnean Society. Vol. I., Nos. 2 and 3. 8vo.—*From the Society.*

Narrative of the Origin and Formation of the International Association for obtaining a uniform Decimal System of Measures, Weights and Coins. By James Yates, M.A. 8vo.—*From the Author.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Wien. Philosophisch-Historische Classe, Band XVI. Heft, 2; XVII., XVIII., XIX.; XX. Heft 1. Mathematish-Naturwissenschaftliche Classe, Band XVI., Heft 2, XVII., XVIII., XIX., and XX. Heft 1. 8vo.—*From the Academy.*

Almanach der Kaiserlichen Akademie der Wissenschaften, Jahr. 1856.—*From the Academy.*

Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, Physik, Mineralogie und Geologie. Herausgegeben von Justus Liebig und Hermann Kopp. Für 1855. 8vo.—*From the Editors.*

Abhandlungen der Koniglichen Gesellschaft der Wissenschaften zu Göttingen. Band VI. 4to.—*From the Society.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen, Amsterdam. Afdeeling Natuurkunde, Deel III. No. 3; IV. Nos. 1–3. Afdeeling Letterkunde, Deel I., II. No. 1.—*From the Academy.*

Berichte uber die Verhandlungen der Koniglich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Philologisch-Historische Classe, 1855, Nos. 3, 4; 1856, Nos. 1, 2. Mathematisch-Physische Classe, 1854, No. 3; 1855, Nos. 1, 2; 1856, No. 1. 8vo.—*From the Society.*

Nachtrag zu Stadtrechte der Latinischen-Gemeinden Salpensa und Malaca in der Provinz Bætica. Von Theodor Mommsen. 8vo. —*From the same Society.*

Nachtrage zur Theorie der Musikalischen Tonverhältnisse. Von M. W. Drobisch. 8vo.—*From the same.*

Elecktrodynamische Maassbestimmungen insbesondere zurückführung der Stromintensitäts-Messungen auf Mechanisches Maas. Von R. Kohlrausch und Wilhelm Weber. 8vo.—*From the same.*

Resultate aus Beobachtungen der Nebelfleeken und Sternhaufen. Von H. D'Arrest. 8vo.—*From the same.*

Berechnung der Absoluten Störungen der Kleinen Planeten. Von P. A. Hansen. 8vo.—*From the same.*

Extrait du Programme de la Société Hollandaise des Sciences à Haarlem, pour l'année 1856. 4to.—*From the Society.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. 2 Verzameling. Deel XI. Stuk 2. 4to.—*From the Society.*

Forhandlingar vid de Skandinaviske Naturforskarnes sjette möte i Stockholm, den 14–19 Juli, 1851. 8vo.—*From the Society.*

Kongl. Vetenskaps-Akademiens Handlingar, för ar. 1853, 1854. 8vo.—*From the Royal Academy of Sciences, Stockholm.*

Ars-Berättelse om Botaniska Arbeten och upptäckter för ar. 1851. Af Joh. Em. Wilkström. 8vo.—*From the same Academy.*

Ofversigt af Kongl. Vetenskaps-Akademiens Forhandlingar. Tolfte argangen, 1855. 8vo.—*From the same Academy.*

Ofversigt af FinskaVetenskaps, Societetens Forhandlingar.—II., III. (1853–56.) 4to.—*From the Society.*

Acta Societatis Socientiarum Fennicæ. Tom. IV. and V., fasc. 1.—*From the Society.*

Recherches Experimentales sur la Végétation. Par Georges Ville. 8vo.—*From the Author.*

Medimalcollegiets Skjæbne. 8vo.—*From the Editor.*

Syphilisationen Studeret ved Syngesengen, af Wilhelm Bœck. 8vo.—*From the Author.*

De Prisca re Monetaria Norvegiæ et de Numis Aliquot et Ornamentis, in Norvegia Repertis. Scripsit C. A. J. Holmboe. 8vo.—*From the Author.*

Kong Christian dens Fejerdes Norske Lovbog, af 1604. Af Fr. Hallager, og Fr. Brandt. 8vo.—*From the Author.*

Om Mundtlig Rettergang og Edsvorne. Af C. Aubert. 8vo.—*From the Author.*

An Historical Summary of the Post-Office in Scotland, compiled from authentic Records and Documents. By T. B. Lang. 8vo.—*From the Author.*

On the Swedish Tabulating Machine of Mr George Schentz. By C. Babbage, F.R.S. 8vo.—*From the Author.*

Annual Report of the Leeds Philosophical and Literary Society, 1855-6. 8vo.—*From the Society.*

Universitatis Regiæ Fredericianæ Novæ ædes Descripsit Ch. Holst, Sec. 8vo.—*From the Author.*

Histology of the Cholera Evacuations in Man and the Lower Animals. By W. Lauder Lindsay, M.D. 8vo.—*From the Author.*

Almanique Nantico para 1857, Calculado de Orden de S.M., en el Observatorio de Marina de la Ciudad de San Fernando.—*From the Observatory.*

Commercium Epistolicum J. Collins et aliorum de Analysi promota, &c., ou Correspondance de J. Collins, et d'autres Savants célebres, du XVII. Siecle relative à l'analyse supérieure. Publiée par J. B. Biot et F. Lefort. 4to.—*From the Ministre d'Instruction Publique et des Cúltes.*

Det Kongelige Norske Frederiks Universitets Aarsberetning for 1853. 8vo.—*From the University.*

Phenomena of the Material World. By D. Vaughan. 8vo.—*From the Author*

On the Practicability of Constructing Cannon of Great Calibre, capable of enduring long-continued use under full Charges. By Daniel Treadwell. 8vo.—*From the Author.*

On the Mechanical Properties of Metals as Derived from Repeated Meltings, Exhibiting the Maximum point of Strength, and the Causes of Deterioration. By W. Fairbairn, F.R.S. 8vo. —*From the Author.*

On Axes of Elasticity and Crystalline Forms. By W. J. M. Rankine, C.E. 4to.—*From the Author.*

Universal Writing and Printing with Ordinary Letters. By Alexander J. Ellis, B.A. 4to.—*From the Author.*

Experimental Researches in Electricity. Thirteenth Series. By Michael Faraday, D.C.L. 4to.—*From the Author.*

On the Action of Non-Conducting Bodies in Electric Induction. By M. Faraday, D.C.L., and P. Riess. 8vo.—*From the Authors.*

Expériences sur la Direction des Courants de l'Océan Atlantique Septentrional. Lettre de S. A. I. le Prince Napoléon à M. Elie de Beaumont, Secrétaire perpétual de l'Académie des Sciences. 4to.—*From the Author.*

Lois Générales de divers ordres de Phénomènes dont l'analyse

dépend d'Equations Linéaires aux Différences Partielles tels que ceux des Vibrations et de la Propagation de la Chaleur. Par L. F. Ménabréa. 4to.—*From the Author.*

Bemærkninger Angaaende Graptolitherne af Christian Boeck. 4to. —*From the Author.*

Report of Committee upon the Experiments conducted at Stormontfield, near Perth, for the Artificial Propagation of Salmon. Read before the British Association by Sir William Jardine, Bart. 8vo.—*From Sir William Jardine, Bart.*

Recherches Cliniques sur la Syphilisation. Par D. Wilhelm Boeck. 8vo.—*From the Author.*

Du Mouvement imprimé à l'Aiguille Aimantée par l'influence subite de la Lumière du Soleil, avec une Théorie nouvelle fondée sur des Recherches faites par H. W. Jacobæus. 8vo.—*From the Author.*

Schädel abnormer Form in Geometrischen Abbildungen, nebst Darstellung einiger Entwickelungs-Zustände der Deckknochen. Von J. Christ. Gustav. Lucae, M.D. Folio.—*From the Author.*

Reports of the Surveyor-General, Charles D. Bell, on the Copper Fields of Little Namaqualand, and of Commander M. S. Nolloth, of H.M.S. "Frolic," on the Bays and Harbours of that Coast. Folio.—*From the Governor, Cape of Good Hope.*

Uber die durch Molekularbenegungen in starren leblosen Körpern bewirkten Formveränderungen. Von Joh. Friedr. Ludw, Hausmann. 4to.—*From the Author.*

Das Chemische Laboratorium der Universität Christiania und die darin Ansgeführten Chemischen Untersuchungen. Herausgegehen von Adolph Strecker. 4to.—*From the University.*

Das Christiania-Silurbecken, Chemisch-Geognostisch Untersucht von Theodor Kjerulf. Herausgegeben von Adolph Strecker. 4to. —*From the University.*

Akademiske Love for de Studerende ved det Kongelige Norske Frederiks Universtet. 8vo.—*From the University of Christiania.*

Uber den Syrisch-Ephraimitischen Krieg unter Jotham und Ahas. Von Dr. C. P. Caspari.—*From the same University.*

Das Normalverhaltniss der Chemischen und Morphologischen Proportionen. Von Adolf Zeising. 8vo.—*From the Author.*

Das Verhältnisk des goldnen Schnitts in seiner Bedeutung für bildende Künstler und Techniker. Von A. Zeising. 8vo. —*From the Author.*

Fagrskinna. Kortfattet Norsk Konge-Saga fra slutningen af det tolfte eller begyndelsen af det trettende aarhundrede. Af P. A. Munch og C. R. Unger. 8vo.—*From the University of Christiania.*

Om Sygepleien i Straffeanstalterne i Norge. Ved Frederik Holst, M.D. 8vo.—*From the Author.*

Michael Skjelderup. 8vo.—*From the Author.*

Beskrivelse over Skotlands Almueskolevæsen tilligemed forslag til forskjellige foramstalt-ninger til en videre Udvikling of det norske Almueskolevæsen. Af Hartvig Nissen. 8vo.—*From the Author.*

Beretning om fante-eller Landstrygerfolket i Norge. Af Cilert Sundt. 8vo.—*From the Author.*

Beretninger om Sygdomsforholdene i 1842 og 1843 i Danmark, Sverige og Norge, oplæste ved de Skandinaviske Naturforskeres Möde i Christiania 1844. 8vo.—*From the University of Christiania.*

Konge—Speilet et Philosophisk-Didactisk Skrift, forfattet i Norge mod Slutningen af det tolfte aarhundrede. 8vo.—*From the same University.*

Aslak Bolts Jordebog. Fortegnelse over Jordegods og Andre Herligheder tilhörende erkebiskopsstolen i nidaros, affattet ved erkebiskop aslak bolts Foranstaltning mellem aarene 1432 og 1449. Af P. A. Munch.—*From the same University.*

Kong Olaf Tryggvesöns Saga forfattet paa latin henimod slutningen af det tolfte aarhundrede af Odd Snorreson. Af P. A. Munch. 8vo.—*From the same University.*

Lycidas ecloga et Musæ Invocatio, carmina quorum auctori Johanni van Leeuwen, e vico zegwaart certaminis poetici præmium secundum e legato Jacobi Henrici Hœufft adiudicatum est in concessu publico Academiæ Regiæ Scientiarum, die 13 Maji, anni 1856. 8vo.—*From the Author.*

Diem Natalem Augustissimi Regis Caroli Joannis ab Universitate

Regia Fredericiana, die 26 Januarii 1838 celebrandum indicit Collegium Academicum. 4to.—*From the University.*

Dr Lorenz Hübner's Biographische Charakteristik. Von Joseph Wiskmayr. 4to.—*From the Royal Academy, Munich.*

Ueber die Gliederung der Bevolkerung des Königreichs Bayern. Von Fr. B. W. Von Hermann. 4to.—*From the same.*

Maps of the Geological Survey of India.—*From the Hon. East India Company.*

Monday, 15th December 1856.

PROFESSOR CHRISTISON, V.P., in the Chair.

The following Communications were read :—

1. On the Ovum and Young Fish of the Salmonidæ. By William Ayrton, Esq. Communicated by Professor Allman.

The paper contained a series of observations on the development of the embryo in the salmon, made on ova procured from an establishment for the artificial propagation of this fish, at Overton, on the river Dee. The author's observations commenced about the 37th day after impregnation, and were continued from that period to the time when the vitellus becomes finally absorbed. The progressive development of the various organs was described, and the principal steps illustrated by carefully drawn and expressive figures. With regard to the proper time for transit, the author arrived at some practical conclusions. He maintained that the ova, after impregnation, should be as little disturbed as possible for the first thirty or thirty-five days, but he proved that at the end of that period they may be exposed to great changes of temperature, and of other external conditions, with comparative impunity; and he was of opinion that they would then endure a transit of some days if only supplied with moisture by means of moss, wool, or similar material. He further concluded, as the result of various observations and experiments, that if the transit be not made when the ovum is from thirty to forty days old, it will be made with most safety after the young fish has attained an age at which the yelk is wholly or nearly absorbed.

2. Notice of the Vendace of Derwentwater, Cumberland, in a letter addressed to Sir William Jardine, Bart., by John Davy, M.D.

In this communication the author first gives an account of the occurrence of the Vendace (a fish hitherto supposed to be confined to the lochs of Lochmaben in Dumfries-shire) in two of the lakes of Cumberland, viz., Derwentwater and Bassenthwaite Lake, in each of which it seems to be pretty abundant, and to have been long known to the boatmen; secondly, he offers some speculative suggestions as to the diffusion of species in the instance of this fish, giving the preference to that presuming that its transfer might have been accidentally effected by the impregnated ova being conveyed by aquatic animals: adducing in favour of this conjecture facts ascertained by him respecting the ova of the Salmonidæ, such as their bearing exposure in a moist atmosphere for days without losing their vitality, and also, with equal impunity, the reduction of their temperature to the freezing point of water, and their entanglement in and adhesion to ice.

3. On the Races of the Western Coast of Africa. By Colonel Luke Smyth O'Connor, C.B., Governor of the Gambia. Communicated by Professor Kelland.

The British possess three colonies on the western coast of Africa: Gambia, 2490 miles from England, in latitude 13° 30′ N., longitude 14° 40′ W.; 500 miles south, Sierra Leone, in latitude 8° 30′ N., longitude 13° 10′ W.; and, 1500 miles down in the Bight of Benin, Gold or Cape Coast Castle, in latitude 5° 5′ 25″ N., longitude 1° 12′ 45″W.

Gambia is selected for this paper, as not only the first, but the most singular and interesting of our African colonies.

Nearly two centuries have glided away since the British, by permission of the kings and chiefs of Combo, established a settlement on the island of St Mary's,—a mere bank of sand, swamp, mud, and mangroves, pregnant with miasma, and well stocked with alligators,—situated near the mouth of the river Gambia, along whose banks we by degrees established small trading ports or factories, until at last we reached Pisania, nearly 300 miles up the river,

where Dr Laidley superintended an extensive trading depôt in 1786, and for years continued the able head and manager of it. But singular enough, with all our wealth, enterprise, desire to extend commerce, and procure channels for the circulation of our home manufactures, we are to the present moment ignorant of the *source and course* of the Gambia; having but hazy, legendary records of the wild tribes adjacent to its banks, or of the children of the desert, the "Foutah Foulahs" and "Foutah Toros," who, rushing down periodically from the interior, devastate districts, plunder whole villages, and bear off into slavery men, women, and children. Our settlements in the Gambia are surrounded by warlike and powerful nations, the kings of Barra, Combo, Badaboo, Kattabar, Woollie being the chief.

The kings of Barra long ruled with despotic sway all the minor sovereigns, and, as their dominions lay adjacent to ours, and extended for several miles along the right bank of the river, we had to conciliate their favour, and submit to their unjust, tyrannical, and insatiable exactions, to preserve intact our struggling settlements of Bathurst, and secure the lives and properties of our merchants trading in the river to Pisania.

The head man of the kings of Barra was, and indeed still is, the "Alkadee of Jillifree," from time immemorial the most powerful chief in the Gambia among the adjacent nations and with the distant tribes. These kings are mentioned by several travellers in Western Africa,—by Johnson in 1621, Stibbs in 1723, Moore in 1737, Dr Laidley, the special friend of the gallant Houghton, in 1791, the enterprising Mungo Park in 1795, and again, when he left Pisania, upon his last fatal expedition to the Niger, in May 1805, by Snelgrove, Winterbottom, Meredith, Houghton, Murray, and many other writers,—as great chiefs, who held the principal sway in the kingdom of Barra. They collected the king's dues (for in former times the kings of Barra levied a duty of £18 on all vessels proceeding up the river Gambia beyond Jillifree), and monopolized the salt trade as far as the kingdom of Woollie; in consideration of which, the kings engaged to redress the wrongs of all traders, factors, agents, or caboceers, who held commerce with them; and did so effectually, by sending a war-man and canoe to any bey, chief, or "sooma," who dared to molest friends belonging to them, that is, under their immediate care.

Two hundred miles up the river Gambia is our most distant military station, M'Carthy's Island, which we purchased from the king of Kattabar. It is about nine miles in length, and one to one and a half in breadth, and forms the principal depôt for the merchants' goods, consisting of blue and white bafts, cotton prints, sugar, guns, gunpowder, tobacco, salt, and rum—the white man's fire water, which has been and is the burning curse—the poisonous draught—the fatal fountain from whence flows the long list of crimes which stain the wild Indian's and the savage African's career for centuries. To it may be traced the bloodiest records in the history of the Old and New World; and the moral, religious, civilized Europeans have a fearful account to answer for.

Beyond M'Carthy's Island the river becomes wilder, more romantic, the banks loftier and more thinly inhabited. Alligators, hippopotami, baboons and monkeys, of great size, and uncommon strength and ferocity, crowd the banks, and follow the steamer or boats with barking and howling, little intimidated by the discharge of fire-arms. The natives entertain a respect, mingled with fear, for the large baboons, and class them with the devil. Indeed, when passing a hill, said to be the especial resort of the devil, the natives salute, not by profound bows, genuflexions, retreating backwards, or flinging dust upon their heads, but by turning their backs, and dancing an antic bolero for some minutes; and they are so firmly persuaded of the necessity of this ceremony, that no promise or reward will induce one of them to pass the *Devil's Hill sans* salutation.

The far-famed Falls of Barraconda, beyond which few white men have advanced, are nothing more or less than shoals, formed by the river rushing over a ledge of sunken rocks, extending diagonally across the channel. In the rains, a vessel can pass over the Falls, and the whole country is inundated for miles.

A few hunters for ivory, or wandering traders, occasionally frequent the Falls, but no factories or settlements extend to this distance. Captain Stibbs, who was despatched by the Duke of Chandos, Director of the Royal African Company, in 1723, proceeded beyond the Falls of Barraconda, until the river became too shallow to float the boats, even when the channel was 160 yards broad. He describes the few natives he met with as a harmless people, who supplied him abundantly with fowls and provisions; but he found him-

self in the region of elephants, river-horses, and baboons. Nearly a century and a half have passed since Stibbs explored the river, and we are not better acquainted with the region of "river-horses" nor of the nature, customs, manners, and habits of the harmless dealers in "fowls and provisions."

The nations not only adjacent to our settlements on the river Gambia, but as far as we carry on commerce, may be classed under the heads of *Mandingoes and Jolliffs*, although divided and subdivided into several tribes bearing different names, such as Warasoonkos, Labous, Surruwoollies, Syreras, Teboos, Tuarics, Jolahs; the last having hardly the features and semblance of human beings. The Mandingo language is soft, musical, poetical, and might be styled the Italian of Western Africa. The Jolliff is harsh, guttural, and confined. Upwards of one hundred dialects are to be met with.

The Arabic character is used for the Koran, general despatches, public or private communications; and the Marabouts instruct the children in the different villages by means of large oval pieces of board, on which letters and sentences from the Koran, or the "Prophet's Laws," are written with a pen made from the common reed. Frequently in my ramblings I have come at night-fall to a Mohammedan town, and after being introduced to my "lodging-man," or landlord, who is bound to protect both my person and my purse, strolling through the narrow closely-fenced paths—for streets they were not—I have reached a small but open space in front of a circular hut, at the door of which was seated a venerable, white-bearded Marabout, surrounded by a crowd of children of all ages, each holding his *wooden* book, and repeating in full chorus, an extract from the Koran, given forth in a clear sonorous voice by the aged instructor.

Polygamy and slavery are the great banes of Western, if not of all Africa. The former checks population, shatters all domestic ties, all kind and friendly feeling; reduces woman to the lowest, most degraded position, so that she becomes the beast of burden, the servant of servants of one tyrannical master.

Slow and uncertain has been our progress in the river Gambia. Since the days of Johnson, in 1621, or Dr Laidley, 160 years afterwards, or Mungo Park, in 1805, to my two trivial expeditions in 1854 and 1856, we are still ignorant of the source of the Gambia; whether (as is vaguely surmised) it connects itself with the Senegal, or flowing southward into the *Niger*, and joining its volume of waters

to those of that singularly obscure and interesting river, empties them, thousands of miles from our settlement at Bathurst, into the Bight of Benin.

The following Donations to the Library were announced:—

The Canadian Journal. New Series. No. 6. 8vo.—*From the Canadian Institute.*

Silliman's American Journal. No. 66. 8vo.—*From the Editors.*

Journal of the Statistical Society of London. Vol. XIX., Part 4. 8vo.—*From the Society.*

Schriften der Universität zu Kiel, 1854, 1855. 4to.—*From the University.*

Bulletin de la Société de Geographie. 4ième Serie, Tom. XI.—*From the Society.*

Abhandlungen herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Band II., 1ste lieferung. 4to.—*From the Society.*

Monday, 5th January 1857.

PROFESSOR CHRISTISON, V.P., in the Chair.

The following Communications were read:—

2. Some Remarks on the Literature and Philosophy of the Chinese. By the Rev. Dr Robert Lee.

2. Observations on the Crinoidea, showing their connection with other branches of the Echinodermata. By Fort-Major Thomas Austin, F.G.S. Communicated by Professor Balfour.

The author remarks, that although there are upwards of 280 writers on the Crinoidea, yet there is no class of ancient animals so much misunderstood. These animals have not merely played an important part in the system of creation as regards animal life, but they have also modified the physical condition of the globe. They are found abundantly in limestones, both of the Silurian and of the Carboniferous epochs, attaining their maximum in the latter. The

author traces the Crinoids, or Encrinites, through various strata, showing the gradual disappearance of ancient forms, and their replacement by new forms of Radiata. The chief characteristics of the Crinoidea, up to the Carboniferous epoch, are, that the articulations which connect the indurated pieces of which the column is composed radiate by simple striæ diverging from the central axis; and that the dorsal portion of the body, that is, the part below the rays, generally preponderates over, or at least is fully equal to, the ventral or upper portion. From this period these older types gradually became extinct, and we find them succeeded by forms in which the ventral portion is generally superior in size to the dorsal, which seems now to serve only as a base for the support of the wide-spreading rays; while, with two exceptions (the Apiocrinus and Gnathocrinus), the articulations in the columns are secured by crenulated floriform ridges on the facets of the joints. This peculiar form attained its maximum in the Lias; since which it has dwindled down to a solitary Pentacrinus, and a few other Crinoids, having little resemblance to the ancient forms.

The author then gives a historical sketch of the various opinions entertained regarding these animals, and notices the superstitious ideas regarding them, whence had originated the names given to them of fairy-stones, giants' tears, St Cuthbert's beads, star-stones, wheel-stones, screw-stones, &c. After alluding to the views of early authors, he proceeds to show the advances which have been made of late in our knowledge of the structure and affinities of Crinoids. He traces the analogies between them and the Echinodermatous tribe. From the Comatula we pass through a succession of forms onwards to the most perfect Echinoderm (the sea-urchin), and backwards to the Marsupite, the Pentacrinus, and the Crinoidea. General affinities exist between the free swimming Euryale and the Marsupite, as well as the fixed Euryalicrinus of the Silurian and Carboniferous rocks.

The analogy between fossil Crinoids and the recent forms of Echinoidea is noticed. The author traces the gradual and uninterrupted transition from the Asteriadæ to the Crinoidea, from the Crinoidea to the Blastoidea, from the latter to Echinida, and finally to the star-fishes.

The following Gentlemen were admitted as Ordinary Fellows:—

Horatio Ross, Esq.
James Black, M.D., Lic. R. Coll. Phys. Lond. F.G.S.

The following Donations to the Library were announced:—

An Analysis of the Statistics of the Clearing House during the year 1839; with an Appendix on the London and New York Clearing Houses, and on the London Railway Clearing House. By Charles Babbage, F.R.S. 8vo.—*From the Author.*

Sanatory Remarks in connection with Nuisances. By Thomas Williamson, M.D. 8vo.—*From the Author.*

Monday, 19th January 1857.

Right Reverend BISHOP TERROT in the Chair.

The following Communications were read:—

1. On the application of the Theory of Probabilities to the question of the Combination of Testimonies. By Professor Boole. Communicated by Bishop Terrot.

The method for the solution of questions in the theory of probabilities which is applied in this paper, is that which was developed by the author in a treatise entitled "An Investigation of the Laws of Thought, on which are founded the Mathematical Theories of Logic and of Probabilities."

The special problems with relation to the combination of testimonies to which the method is applied are the following, viz.:—1*st*, That in which the testimonies to be combined are merely different numerical measures of a physical magnitude, as of the elevation of a star, furnished by different observations taken simultaneously. 2*d*, That in which the testimonies to be combined relate, not to a numerical measure, but to some fact or hypothesis of which it is required to determine the probability; the probabilities furnished by the separate testimonies being given.

Before proceeding to the solution of these problems, the author notices a distinction between problems (relating to probabilities) of which the elements are logical, and problems of which the elements cannot, without being subjected to some previous mental transformation, be regarded as logical. He describes as logical those problems in which the data are the probabilities of certain simple events, and the quæsitum the probability of some compound event, whereof the simple events are the elements combined in any way as happening or not happening. If, for example, the probabilities that the individuals A, B, C, will continue in life for ten years, be p, q, r, given fractions, and the quæsitum be the probability of all the lives continuing, or of their all failing, or of any two falling and one continuing; these he calls logical problems. In like manner, if the data be the probabilities of such compound events, and the quæsitum be the probability of some other compound, or of the simple events compounded, these also are logical. This the author expresses generally.

Given prob. $\phi_1(x, y, z)$, prob. $\phi_2(x, y, z)$, &c.; find prob. $\psi(x, y, z)$.

It may be observed, that as an event must either happen or not happen, these functions can consist only of factors of the form x and $1-x$. He observes,—"I regard the elements of a problem relating to probability as logical when the numerical data are the probabilities, in the mathematical sense, *i.e.*, measures of probability of certain events, and when the object sought is the probability of some other event whose connection with the former is either,—1*st*, That it is a compound event of which they are the simple components; or, 2*d*, That both it and they may be resolved into the same components. He employs the term 'compound event' to denote, not merely the conjunction of certain simple events, but any kind of combination of them in the way of happening or not happening, happening together, or in alternation; or in any way which is capable of being expressed by the grammatical forms of language, and especially by the adverb *not* and the conjunctions *and*, *either*, *or*, &c.

According to this definition, the problem of the reduction or combination of different simultaneously-observed altitudes of a star is not in its direct presentation a logical one. The immediate data are not probabilities of events, but measures of a physical magnitude. The author, however, remarks that this problem is capable of being

reduced to a form in which its elements are logical. If a quadrant of the celestial arc be taken as the unit of magnitude, then any observed elevation of a star, regarded as a physical point, in a particular quadrant of elevation, will be the probability furnished by that observation, that a pointer directed at random to the given quadrant will point somewhere below the star.

This is clear from the ordinary definition of the measure of probability. For, supposing the observed altitude to be 10°, then the number of different directions that may be given to the pointer, is to the number of such directions falling below the star, as 90 : 10, or as 9 : 1. Hence the probability of the direction of the pointer being below the star at $\frac{1}{9}$ = the altitude of the star, considering the quadrant as unity.

In considering this problem, the author first makes some observations on the different principles which have been employed in its discussion, viz.: the principle of the arithmetical mean regarded as axiomatic in its nature, the principles of mechanical analogy, of geometrical consistency, &c. And he suggests that the agreement of results deduced in such various ways is to be taken as an evidence of a certain harmony between the intellectual powers and the external universe considered as their actual sphere of exercise.

Reducing the problem, as above intimated, to logical elements, he then applies to it the method developed in the "Laws of Thought." The following, though not the most general, is the most interesting result to which the application leads:—

If n observations of the altitude of a star are to be combined, and if $c_1, c_2, \ldots c_n$ are the several probabilities that these respective observations are absolutely correct, and if $p_1, p_2, \ldots p_n$ are the altitudes which they furnish, then the most probable altitude will be

$$\frac{\frac{C_1}{1-C_1}p_1 + \frac{C_2}{1-C_2}p_1 \cdots + \frac{C_n}{1-C_n}p_n}{\frac{C_1}{1-C_1} + \frac{C_2}{1-C_2} \cdots + \frac{C_n}{1-C_n}} \quad (1.)$$

This result is in accordance with the familiar form

$$W_1 p_1 + W_2 p_2 \cdots + W_n p_n$$

where W_1 W_2 . . . W_n represent what are termed the *weights* of the observations. But it is free from any admixture of mechanical analogy, and it expresses the so-called *weights* as functions of certain initial *probabilities*, viz.: the several probabilities of absolute correctness in the observations. Even if these probabilities are, as in

theory they must be, infinitesimal, the values of $W_1\ W_2 \ldots W_n$, which depend upon *ratios* will be finite. If any one of the quantities $C_1, C_2 \ldots C_n$, is equal to unity, the formula verifies itself; for if it is certain that if an observation be correct, the result which it furnishes must be adopted.

If $C_1 = 1$, then $\frac{C_1}{1-C_1} = \frac{1}{0}$ = infinity. Therefore, the expression becomes

$$\frac{\frac{C_1}{1-C_1}p}{\frac{C_1}{1-C_1}} = p_1$$

If $C_1\ C_2 \ldots C_n$ are equal, the formula degenerates into

$$\frac{p_1 + p_2 + \ldots p_n}{n} \ldots\ldots (2.)$$

and expresses the principle of the arithmetical mean.

The author conceives this investigation to be of value, not on account of the result to which it conducts us, but on account of the connexion which it establishes between the doctrine of the arithmetical mean and the logical theory of probabilities.

In the second special problem, viz., the problem of the combination of testimonies to a fact or hypothesis, results are obtained which may thus be described:—

1*st*, The complete solution involves arbitrary constants, and is therefore indefinite. It admits, however, in various cases of a definite value, and leads to many general conclusions of considerable interest.

2*dly*, The arbitrary constants relate, not to the probability of the fact or hypothesis as dependent upon the testimonies or evidences, but to the probabilities of the testimonies themselves. Thus, if two symptoms are observed, each of which gives a certain probability of the existence of a disease, the strength of the joint presumption does not altogether depend upon that of the separate presumption, but is affected, for instance, by the *à priori* likelihood of concurrence of the symptoms.

3*dly*, In general, combined presumptions would be strengthened by the *à priori* unlikelihood of their combination.

4*thly*, In many cases the arbitrary elements disappear. Thus, if one of the presumptions amount to certainty, the combination will always indicate certainty, however unfavourable the opposite presumption may be.

5*thly*, Where testimonies are in a high degree cumulative, *e.g.* where their concurrence was *à priori* very improbable, the formula for the strength of the united testimonies $p_1, p_2, \ldots p_n$, tends to assume the following expression as its limits, viz.:—

$$\frac{p_1 p_2 \ldots p_n}{p_1 p_2 \ldots p_n + (1-p_1)(1-p_2) \ldots (1-p_n)}$$

This is commonly assumed to be the general solution. The author shows that the proof of it, as usually given, involves the neglect of a real and important consideration,—viz., that it is to the *same* fact that the testimonies relate. To the true general solution it stands in the position of a limiting value, applicable only on the hypothesis of the testimonies being of a very unexpected kind, or of their concurrence being very unexpected.

6*thly*, When the probabilities are not cumulative, but some of them are felt to be too great, others too small, and a kind of mean between them is required, a definite result is again obtained, which may be thus stated.

Let $p_1, p_2, \ldots p_n$, represent the separate probabilities, then is the mean probability represented by the formula

$$\frac{(p_1 p_2, \ldots\ldots p_n)^{\frac{1}{n}}}{\left\{p_1 p_2 \ldots p_n\right\}^{\frac{1}{n}} + \left\{(1-p_1) \quad (1-p_2) \ldots (1-p_n)\right\}^{\frac{1}{n}}} \qquad (3.)$$

This formula is the counterpart of (2). It expresses the average of the probabilities furnished by differing judgments, even as the formula of the arithmetical mean expresses the average among differing measures of a numerical magnitude. But it differs in character and in the consequences which it involves from the latter formula.

Thus if the testimonies are two in number, and the probabilities which they furnish in favour of an event are p and q, the formula becomes $\dfrac{\sqrt{p\,q}}{\sqrt{p\,q} + \sqrt{(1-p)(1-q)}}$, and furnishes a value which does not lie half-way between the values p and q, but which, as may easily be shown, lies nearer to the one of those values which is the nearer either to 1 or to 0. This indicates, that if we have to take an average between two judgments, one of which partakes more of the character of certainty than the other, the former will have greater weight in determining the final state of expectation. This, the author observes, is accordant with our instinctive feelings.

The formula, it is to be observed, is not applicable to cases in

which evidence is of a cumulative character, as where different positive assertions are made of the absolute truth of a fact,—but to cases in which different modes of considering a subject lead us to assign different probabilities to a fact or hypothesis, and it is our object to take between these probabilities an average.

For example if A and B, whose veracity, that is the probability of their speaking truth, has a given value, both affirm that the event E has occurred, the formula does not apply. The proper, at any rate the received, formula for such a problem is $\frac{pq}{pq + \overline{1-p}\,.\,\overline{1-q}}$

But if the question be the probability that Sir Philip Francis was the author of Junius' Letters, and p and q be the probabilities derived from external and internal evidence, then the formula $\frac{\sqrt{pq}}{\sqrt{pq} + \sqrt{\overline{1-p}\,.\,\overline{1-q}}}$ applies.

In that portion of the memoir, which is introductory to the demonstration of the above results, the author explains the grounds of his method for the solution of questions in the theory of probabilities whose elements are logical. They are briefly the following :—

1*st*, He defines the mathematical probability of an event, as the ratio which the number of cases or hypotheses favourable to that event bears to the whole number of cases conceivable, supposing that to none of those cases the mind is entitled to attach any preference over any other.

2*dly*, He remarks, that when the probabilities of simple events constitute our only data, no knowledge whatever being given of their connection, we can thence, by virtue of the definition, determine the probability of any logical combination of them, either absolutely or conditionally.

3*dly*, He postulates that when the data are not the probabilities of simple events, we can only grasp them and apply them to the calculation of probability by regarding them, not as primary, but as derived from some hypothesis in which the data are the probabilities of simple events, and to which, accordingly, we may apply the principles already referred to, as flowing from the very definition of probability. The probabilities of the simple events in the hypothesis must, of course, be determined in accordance with the original data.

At this stage the question arises, How shall such an hypothesis be lawfully framed? To this question the following answer is given.—

4thly, When, as in the case supposed, the data are not the probabilities of simple events, the numerical measures of probability p, q, r, &c., which they involve, will be subject to certain conditions (beside that of their being positive fractions), in order that these data may be mutually consistent,—may, if considered as furnished by experience, represent an experience which is *possible*. These conditions the author terms the "conditions of possible experience," and he gives a general method for their determination. Thus, for example, if p is the probability of the conjunction of the events x and y, q of the conjunction of y and z, and r of the conjunction of z and x, the quantities p, q and r, besides the condition of not transgressing the limits 0 and 1, must satisfy the conditions

$$p \overline{\overline{\gtrsim}} q + r - 1, \; q \overline{\overline{\gtrsim}} r + p - 1, \; r \overline{\overline{\gtrsim}} p + q - 1;$$

similar conditions deducible from the data, will in general, limit *à priori*, the value of the probability sought.

5thly, The author then lays down the principle, that the hypothetical construction (already referred to) of the problem from simple events with unknown probabilities, must be such, that the determination of these unknown probabilities from the data will be possible and definite, when the above conditions of possible experience are satisfied. In other words, the hypothesis should involve the existence of no other conditions among the data, than the condition of their being possible, and mutually consistent.

This principle, he observes, completely limits and determines the nature of the solution, restricting it to the particular method developed in the chapters on probability in the Laws of Thought. He remarks, that the method in question was not, however, as it first presented itself to his own mind, associated with such considerations as these, nor are such considerations even hinted at in the work referred to. The method was there exhibited as resting upon an axiomatic basis. The fact, that the conditions which it involves as conditions of mathematical validity and consistency, are identical with the conditions of possible experience, was subsequently discovered.

The proof of this identity, is not, however, in its present state, to be considered as complete; neither can it be considered as established that no other method can satisfy the so-called conditions of possible experience. The proof of the former proposition has, however, been carried sufficiently far to leave no doubt of its truth, and the latter

one has in its favour the negative evidence furnished by the failure of solutions attempted by competent analysts upon other grounds.

2. On New Species of Marine Diatomaceæ from the Firth of Clyde and Loch Fine. By Professor Gregory. Illustrated by numerous drawings, and by enlarged figures, all drawn by Dr Greville.

In two papers, read before this Society, and subsequently published in the Microscopical Journal, I described and figured a large number of new species of Diatoms, chiefly marine, which I had found in the Glenshira sand.

This sand was deposited by the Dhu Loch of Glenshira, at a period geologically recent, when that lake occupied a higher level than it now does, and extended about two miles farther up the valley. That the Dhu Loch at that period, as well as now, communicated with Loch Fine, so that at high tide the salt water flowed into the lakes, while at low water the current, as in a tidal estuary, flowed outwards, is proved by the fact, that the sand then deposited contains more marine than fresh-water species. In the deposit now forming in the Dhu Loch marine forms are also abundant.

But while it was obvious that all the marine forms of the Glenshira sand had come from Loch Fine, itself a branch of the Firth of Clyde, it was remarkable that the new forms I had described should not have been found in the Clyde by those who had examined its deposits. There was indeed one form which I had figured, namely *Navicula Hennedyi*, which Mr Hennedy had shortly before observed in the Clyde, but which had not yet been described. Many known forms were also common to the Glenshira sand and to the Clyde.

Being firmly convinced that the new forms had also, so far at least as they were of marine origin, come from the Clyde, I resolved to explore such Clyde deposits as I could obtain; and having procured several, the result has entirely confirmed my anticipations, and has, besides, brought to light a large number of additional undescribed forms.

The materials I have examined are 11 in number, of which, 3 were from Lamlash Bay, one from *Corallina officinalis*, taken from pools on the shore of Arran at Corriegills, and 7 from Loch Fine, four of these having been dredged by the Duke of Argyll and myself

off Inveraray, and 3 having been dredged off Strachur by the Rev. Dr Barclay.

For one of the dredgings from Lamlash Bay I am indebted to Professor Allman; the others from that quarter were sent to me by the Rev. C. P. Miles, M.D.

All were more or less interesting. The richest was that of Professor Allman, which was simply the dirt washed from some nests of Lima hians, dredged in 4 fathoms. One of Dr Miles's was also from these nests in 7 fathoms, and was not so rich, though still full of new forms. Those from Loch Fine were from depths varying from 14 to 60 fathoms.

No two were alike, except that the two just mentioned, from the nests of Lima, in nearly the same locality, were more like each other than any of the others. This variety is very curious, when we reflect that over a large extent of the bottom of the Atlantic the recent soundings have exhibited an astonishing similarity, being, however, entirely different from our estuarial deposits of the Clyde, and very poor in Diatoms.

The variety just alluded to shows that the deposits of as many localities as possible, even in the same estuary, should be examined, and that we cannot beforehand know what they are likely to yield. It is not at all likely that 11 dredgings, from three localities, and all different, should have exhausted the undescribed forms of the Firth of Clyde.

I. These materials yielded a very large number of known species, among which were a good many which have hitherto been extremely rare. Such are, for example,

Navicula Hennedyi, Sm.
„ granulata, Bréb.
„ Lyra, Ehr.
Pleurosigma transversale, Sm.
„ obscurum, Sm.
„ delicatulum, Sm.
„ rigidum, Sm.
Stauroneis pulchella, β Sm.
Coscinodiscus concinnus, Sm.
Eupodiscus crassus, Sm.
„ Ralfsii, Sm.
Eupodiscus sculptus, Sm.
Campylodiscus Horologium, Sm.
Podosira Montagnei, Sm.
„ maculata, Sm.
Orthosira marina, Sm.
Surirella lata, Sm.
„ fastuosa, Sm.
Biddulphia Baileyi, Sm.
„ turgida, Sm.
Grammatophora macilenta, Sm.
Syndendrium Diadema, Ehr.

Perhaps the most interesting among these forms, is *Campylodiscus Horologium*, which very few observers had seen, as it had only occurred very sparingly in a dredging made on the Coast of Skye by Mr G. Barlee, and examined by Professor Williamson. I have now a tolerably abundant supply of it, chiefly from Loch Fine, but it

occurs also in Lamlash Bay. *Eupodiscus sculptus* occurs twice or three times the size of Professor Smith's figure, and *Eupodiscus Ralfsii* occurs, in the Corallina material, of remarkable size and beauty, and in great abundance. Discs of this fine species, from 0·005″ to 0·007″ in diameter, are frequent, and some even reach the diameter of 0·008.″ *Orthosira marina* (*olim Melosira sulcata*) is very abundant in Lamlash Bay. *Syndendrium Diadema*, figured by Mr Brightwell in his paper on Chætoceros, is not rare in Lamlash Bay. It has not, I believe, been yet described as a British species.

II. As I anticipated, these materials have yielded almost every one of the new forms of the Glenshira sand.

I have recognised the following :—

Navicula maxima, α and β
„ angulosa, α and β
„ latissima.
„ humerosa.
„ clavata.
„ incurvata.
„ splendida.
„ didyma γ, costata.
„ didyma δ
„ formosa.
„ rhombica.
Pinnularia Pandura, Bréb.
„ inflexa.
„ longa.
„ fortis.
Cocconeis distans.
Cocconeis costata.
Amphiprora recta.
„ lepidoptera.
„ minor.
Amphora Arcus
„ Grevilliana.
„ obtusa.
„ crassa.
„ plicata.
„ elegans.
„ lineata.
„ rectangularis.
Tryblionella constricta.
„ apiculata.
Campylodiscus simulans.
Synedra undulata.

It is impossible to doubt, that the few remaining Glenshira marine forms will yet be found in the Clyde, perhaps even in these dredgings; if not, in others.

III. Besides the above forms, all of which I had figured, there had occurred in the Glenshira sand 7 or 8 forms, the study of which I had postponed, either from want of good specimens, or from their extreme scarcity in that deposit. By the help of the new materials, I have been enabled to clear up, and to establish as distinct species, every one of these forms, most of which are very curious and interesting.

IV. Lastly, I have detected, in these materials, a very large number of new species. These I have arranged in the following groups.

Group I.

Naviculoid Forms.

1. Navicula minor, n. sp.
2. „ Cluthensis, n. sp.
3. „ inconspicua, n. sp.
4. „ brevis, n. sp.
5. Navicula Claviculus, n. sp.
6. „ Musca, n. sp.
7. „ rectangulata, n. sp.
8. „ nebulosa, n. sp.

9. Navicula Barclayana, n. sp.
10. „ spectabilis, n. sp.
11. „ prætexta, Ehr.
12. „ Bombus, Ehr.
13. „ Lyra, Ehr.
14. „ Lyra, var. β, abrupta.
15. „ Smithii, var. β, fusca.
16. Navicula Smithii, var. γ, nitescens.
17. „ Smithii, var. δ, suborbicularis.
18. „ maxima Greg.
19. Pinnularia subtilsi, n. sp.
20. „ rostellata, n. sp.
21. „ Allmaniana, n. sp.
22. „ Pandura, Breb, var.

I have given a figure of the typical *N. Lyra*, Ehr., not yet figured as a British form. The figure referred to by Professor Smith in his second vol. (vol. i. fig. 152$\overset{*}{a}$) is that of the variety β.

I exhibit drawings of all the most remarkable of these forms, and an enlarged figure of *N. prætexta*, Ehr., which is not only remarkable and beautiful in itself, but interesting from the circumstances in which it occurs.

Ehrenberg found it only fossil, in the Clay Marl of Ægina, where it seems to be very scarce, as he has figured an imperfect specimen. I have found it recently, both in Lamlash Bay and Loch Fine, and though not abundant, yet sufficiently frequent to have enabled me to distribute a good many specimens. No doubt, if we persevere in examining the estuarial deposits, we shall some day find it in greater abundance in the vicinity of its proper habitat.

Here, then, is a form which, till now, has been regarded as fossil only, which is found to be still existing in the Clyde. The Clay Marl of Ægina is stated by Ehrenberg to belong either to the chalk formation, or to the oldest tertiary or eocene beds. I have selected this form, because the bed in which it occurs fossil is the oldest in which Ehrenberg has found any Diatoms. He has, indeed, found microscopic organisms in the chalk, and even in older rocks, among which he mentions the Mountain Limestone and the Silurian Green Sand. But the forms in the two latter rocks are not numerous, and, as well as those which abound in the chalk, belong to the Foraminifera or to the Polycystineæ, not to the Diatomaceæ.

We find, then, that this very remarkable form, which occurs fossil in the Clay Marl of Ægina, exists in the Clyde at the present day; and there is no difference whatever between the fossil and the recent specimens.

But this is not all. In the same Clay Marl Ehrenberg has figured many more species of Diatoms, and of these, upwards of three-fourths are absolutely identical with forms which abound in the Clyde. Such are *Navicula Bombus*, *N. incurvata*, *Pinnularia Pandura*, *Orthosira marina*, *Amphitetras antediluviana*, *Tricer-*

atium Favus, *Actinocyclus undulatus*, *Coscinodiscus radiatus*, several Grammatophoræ, and various others.

In short, I have no hesitation in saying, that I believe all the forms in the Ægina Clay Marl, which is the oldest Diatomaceous deposit yet described, will be found living on our coasts.

It may also be observed, that of all the forms figured by Ehrenberg from more recent strata, whether miocene, like the bed on which the town of Richmond, Virginia, is built, and several kinds of Bergmehl, or pleiocene, like other Bergmehls and polishing slates, &c., or still more recent, the great majority are perfectly identical with existing Diatoms.

Indeed, although many forms are stated in Ehrenberg's earliest writings to be fossil only, and have been supposed to be extinct, the progress of observation is continually adding to the number of species which are found also in the recent state. Thus, for example, the whole group of dentate Eunotiæ, which abound in the Lapland and Finland Bergmehls, were long thought to be only fossil. But they have been nearly all found living in America, and I have myself seen several of them recent in this country. *Eunotia triodon*, long supposed to be extinct, occurred scattered in many of the Scottish fresh-water gatherings I described in this place three years ago, and I found it this last summer the predominant form in a gathering brought from Arran by Dr Balfour.

Taking these facts into consideration, I am led to believe that we have no evidence that any species of Diatom has become extinct, as so many species, and even genera and tribes, of more highly organized beings have done. I observe that Mr Brightwell expresses a similar opinion in his valuable paper on Chaetoceros. (See Micr. Jour. IV. 105.) His anticipation that Syndendrium would be found recent has been fulfilled. (See List, p. 450.) Our knowledge of the existing species is yet very imperfect, as is obvious from the facts adduced in this paper, in which so many undescribed forms are shown to exist in a few localities of one estuary. And among these are such forms as the present one, *N. prætexta*, which has hitherto been supposed only to exist as a fossil.

It is well known, that in certain animal tribes, Molluscs, for example, many species are common to the present and to earlier geological periods. I need only allude to the circumstances that the eocene, miocene, and pleiocene strata are named from their propor-

tions of existing to extinct molluscs, and that the Terebratula of the Silurian epoch is found to exist at the present day.

But in the case of Diatoms, there is reason to think that the whole of the species which occur fossil will, ere long, be detected in the recent state, just as has occurred in the case before us, *N. prætexta*, which, it must be remembered, occurs in the oldest Diatomaceous deposit yet described, and along with forms, nearly all of which I have actually found in the Clyde.

It is at all events certain, that a very large proportion of the Diatoms found in the fossil state also occur in the living state, and that every day adds to their number.

There is at present no good evidence of the existence of Diatoms earlier than the Chalk, if so early. But we must not forget that the shells of Diatoms appear to be altered by long contact with carbonate of lime, so that they may have existed at one time in the Chalk. We find them, however, in spite of the action of calcareous matter, in the Chalk Marls of Meudon and of Caltanisetta, which are rather more recent than the Chalk, and probably about the age of the Clay Marl of Ægina. If, as I believe, no Diatoms have become extinct, this may, perhaps, depend on their minute size and extreme simplicity of structure, which probably render them more indifferent to climatic changes than more highly organized and larger beings.

We have evidence, to a certain extent, that this is the case; for by Ehrenberg's figures it appears, that in gatherings of recent Diatoms, from all parts of the world, in every possible variety of climate, the majority of the species are identical with our own.

Diatoms, therefore, are not materially affected by existing differences of climate, and have probably been as little affected by the geological changes which have occurred, at all events since the period of the eocene deposits.

To return to the new forms.

Group II.

Cocconeides.

The number of new forms in this group is not large, but they are all interesting. They are as follows:—

23. Cocconeis distans, W.G.
24. „ dirupla, n. sp.
25. „ ornata, n. sp.
26. „ nitida, n. sp.
27. Cocconeis pseudomarginata, n. sp.
28. „ major, n. sp.
29. „ splendida, n. sp.

The first I have figured a second time, because I have detected in it a character which effectually distinguishes it from *C. Scutellum*. The second is one of those Glenshira forms, which I have been enabled by the new materials to study and distinguish. I exhibit drawings of them, and enlarged ones of *C. nitida*, *C. splendida*, and *C. pseudomarginata*, which are very striking forms. *C. major* is equally remarkable.

Group III.

Filamentous Forms.

Of these, there are a good many, and most of them are curious.

30. Diadesmis? Williamsoni=Himantidium Williamsoni, Sm.
31. Denticula marina, n. sp.
32. „ distans, n. sp.
33. „ minor, n. sp.
34. Denticula? nana, n. sp.
35. „ ? fulva, n. sp.
36. „ ? staurophora, n. sp.
37. Denticula? lævis, n. sp.
38. „ ? capitata, n. sp.
39. „ ? interrupta, n. sp.
40. „ ? ornata, n. sp.
41. Meridion ? marinum, n. sp.
42. Pyxidicula cruciata, Ehr.
43. Orthosira angulata, n. sp.

The first species was described by Professor Smith, but doubtfully, as a Himantidium, the F.V. only being then known. The S.V., which abounds in some of the dredgings, proves that it is not a Himantidium; but it is not so easy to say to what genus it belongs. Diadesmis is not admitted by Professor Smith, but comes nearer to it than any of his genera. It has also some analogy with Achnanthes, as well as with Odontidium and Denticula. I give the genus, therefore, with a mark of doubt. The four next agree pretty well with Denticula; but the six which follow them are all very doubtful as to genus, although, perhaps, nearer to Denticula than to any other genus admitted by Smith. The next form has strong analogies with Meridion, and even with Gomphonema. I do not venture here to decide on the genera of these forms, but content myself with indicating the existence of the species. *Pyxidicula cruciata* is a form, long described by Ehrenberg as fossil; indeed it occurs in the Ægina Clay Marl, already mentioned; and in the miocene deposit of Richmond, Virginia. I do not know that it has ever been found recent, till now. *Orthosira angulata* is very abundant in Lamlash Bay, and its disc has probably been described as *Coscinodiscus minor*, by Kützing and others. But it is a true Orthosira.

Group IV.

Discs and Campylodisci.

These, though not very numerous, are very interesting—

44. Coscinodiscus centralis, Ehr.	50. Eupodiscus subtilis, Ralfs.
45. „ nitidus, n. sp.	51. Campylodiscus Ralfsii, Sm.
46. „ umbonatus, n. sp.	52. „ centralis, n. sp.
47. „ punctulatus, n. sp.	53. „ angularis, n. sp.
48. „ concavus, Ehr.	54. „ eximius, n. sp.
49. Melosira ? n. sp.	55. „ limbatus, Bréb.

It will be seen, that two of these forms have been described by Ehrenberg, who figures them in the fossil deposits above alluded to, and one by De Brébison, who found it near Cherbourg. The form to which Mr Ralfs's name is attached was supposed by him to be *Coscinodiscus concinnus*, Sm., but proves to be a very remarkable Eupodiscus. I had not seen it when Mr Ralfs first observed it; but since then, Dr Greville observed it on one of my slides, and I have myself repeatedly noticed it since. I give a figure of it, as it has not yet been figured. *Campylodiscus Ralfsii* I figure, because it occurs in these dredgings, twice or thrice the size of Professor Smith's figure, from which, moreover, it differs in several points; but I believe it to be the same species. The remaining forms are new and remarkable. That which I suppose to be a Melosira is doubtful as to genus.

Group V.

Amphiproræ.

There are not many new species of this genus, but all of them are remarkable.

56. Amphiprora lepidoptera, n. sp.	60. Amphiprora plicata, n. sp.
57. „ obtusa, n. sp.	61. „ maxima, n. sp.
58. „ pusilla, n. sp.	62. „ ? complexa, n. sp.
59. „ elegans, Sm.	

The first was described, and the F.V. figured in my last paper on the Glenshira sand; while the S.V. had been figured in my first paper as *Amphiprora vitrea* β. But as both figures were imperfect, and the form not quite understood, I have now figured it again. The remaining species, except No. 59, are all new and distinct, and *Amphiprora maxima* is a splendid form.

The last is a very remarkable form, which I doubtfully refer to the same genus. Segments of it had occurred in the Glenshira sand, but it was only in the Corallina gathering that I found the entire form. I exhibit enlarged figures of *Amphiprora maxima*, and of *Amphiprora ? complexa*, both the segments and the entire form.

Group VI.

Amphoræ.

This group is by far the largest, containing upwards of thirty

new species, in addition to the new Amphoræ of the Glenshira sand, which, as already stated, also occur in these materials. I have found it necessary to divide them into two series, the simple and the complex.

A.—Simple Amphoræ.

63. Amphora turgida, n. sp.
64. „ augusta, n. sp.
65. „ nana, n. sp.
66. „ macilenta, n. sp.
67. „ lineata, Greg.
68. „ ventricosa, n. sp.
69. „ binodis, n. sp.
70. „ monilifera, n. sp.
71. „ Ergadensis, n. sp.
72. Amphora oblonga, n. sp.
73. „ spectabilis, n. sp.
74. „ robusta, n. sp.
75. „ truncata, n. sp.
76. „ lævis, n. sp.
77. „ lævissima, n. sp.
78. „ dubia, n. sp.
79. „ Proteus, n. sp.
80. „ pellucida, n. sp.

B.—Complex Amphoræ.

81. Amphora Arcus, Greg.
82. „ crassa, Greg.
83. „ Grevilliana, Greg.
84. „ complexa, n. sp.
85. „ fasciata, n. sp.
86. „ sulcata, Bréb.
87. „ excisa, n. sp.
88. „ nobilis, n. sp.
89. „ Milesiana, n. sp.
90. Amphora lyrata, n. sp.
91. „ proboscidea, n. sp.
92. „ cymbifera, n. sp.
93. „ quadrata, n. sp.
94. „ elongata, n. sp.
95. „ acuta, n. sp.
96. „ pusilla, n. sp.
97. „ bacillarus, n. sp.
98. „ granulata, n. sp.

I exhibit enlarged figures of one or two from each division.

The first three species in the list of complex Amphoræ have been already figured from the Glenshira sand, but imperfectly, and in one case erroneously; I therefore figure them again, as they are now better understood. This complex group, of which a short time since only one was known, namely,—*A. costata*, Sm., has now become a very large one, and the remarkable structure of the forms included in it, which had hardly been attended to in *A. costata*, is found to be of very frequent occurrence. It is probable that these complex forms will require the establishment of a new genus; but in the meantime I regard them as forming a well-marked sub-genus.

There are still several species of Amphoræ to be added to the long list already given; but they have not yet been fully studied, for want of time.

Group VII.

Miscellaneous.

A few forms are here added, which do not enter into the groups already named, or were observed too late.

99. Navicula ? Libellus, n. sp.
100. Nitzschia ? panduriformis, n. sp.
101. Nitzschia distans, n. sp.
102. „ hyalnia, n. sp.
103. Pleurosigma reversum, n. sp.
104. Sceptroneis Caduceus, Ehr.
105. Synedra undulata, Greg. =Toxarium undulatum, Bail.
106. Synedra Hennedyana, n. sp.

The first of these forms resembles *N. rhombica*, figured as occurring in the Glenshira Sand. Both forms are doubtful as to genus, and may possibly prove to be Schizonemata. The second is allied to Tryblionella as well as to Nitzschia. The fifth, *Pleurosigma reversum*, is a very singular form, the genus of which is not quite certain. The sixth is of a genus new to Britain, and is one of the forms hitherto believed to be fossil only. The next, *Synedra undulata*, has not yet been figured entire as a British form. The form which follows closely resembles it except that it has no undulations in the margin.

In an appendix, I have added a full description and a figure of a very fine new species, detected by Professor Arnott in a gathering from Teignmouth, and subsequently found, by the same observer, in one from the Clyde, which justifies its introduction here. The figure and description are by Dr Greville.

The new form, *Creswellia Turris*, Arnott, belongs to an entirely new genus, which is allied to Pyxidicula, but differs from that genus as described by Ehrenberg, in forming filaments or chains. It will be remembered, that I have also detected a Pyxidicula in the Clyde, so that both these allied genera occur in that estuary.

3. Short Verbal Notice of a simple and direct method of Computing the Logarithm of a Number. By EDWARD SANG, Esq.

Mr Sang briefly explained an application of the method of continued fractions to the resolution of the exponential equation, and illustrated it by exhibiting the computation of the logarithm of the prime number 27073 directly.

The following Donations to the Library were announced:—

Publications of the Ælfric Society, viz.—

1. The Homilies of Ælfric, with an English Translation. By Benjamin Thorpe, F.S.A. 2 vols. 8vo.—London, 1843–1846.
2. The Poetry of the Codex Vercellensis, with an English translation. By J. M. Kemble, M.A. 8vo.—1844–1856.

3. Anglo-Saxon Dialogues of Salomon and Saturn. By John M. Kemble, M.A. 8vo.—1845–1848.
From William Ivory, Esq., W.S.

Catalogue of the Law Books in the Library of the Society of Writers to Her Majesty's Signet in Scotland. By William Ivory, W.S. 8vo.—Edinburgh, 1856. *From the Author.*

Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, Physik, Mineralogie und Geologie. Herausgegeben von Justus Liebig und Hermann Kopp, 1855, Zweites Heft. 8vo. *From the Editors.*

Memorias de la Real Academia de Ciencias de Madrid, Tom. III. and IV. 4to.—Madrid, 1856. *From the Academy.*

Programa para la adjudicacion de premios en el ano 1857. *From the same.*

Anuncio del Eclipse anular y Central que tendra lugar el 15 de Marzo de 1858. Por Don Antonio Aguilar. 8vo.—*From the Author.*

Assurance Magazine, and Journal of the Institute of Actuaries, No. XXVI., January 1857.—*From the Institute.*

Percement de l'Isthme de Suez. Rapport et Projet de la Commission Internationale. 8vo.—Paris, 1856. *From the International Suez Canal Company.*

Flora Batava. 180 Aflevering. 4to.—*From the King of Holland.*

Monday, 2d February 1857.

THE RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read:—

1. On the Urinary Secretion of Fishes, with some remarks on this secretion in other classes of animals. By John Davy, M.D., F.R.S., London and Edinburgh.

The urinary secretion of fishes, the author believes, has hitherto received so little attention owing to certain difficulties attending its investigation. He brings forward the few and imperfect observations he has made, with the hope of inducing others more favourably situated to prosecute the inquiry.

The fishes he has examined in quest of their urinary secretion

have been fifteen; of those with a urinary bladder he found a fluid only in three, the Perch, Ling, and Ray; and in those without this organ, only in two, in their ureters—those of the Pike and Turbot.

His experiments to ascertain the composition of the secretion were attended mostly with negative results. In one instance, that of the Pike, he detected lithic acid; in some others there were indications of the presence of urea in the fluid urine.

The conclusions he ventures to draw are, that the secretion is small in quantity, mostly liquid, and that urea or some other analogous nitrogenous compound is its principal ingredient.

For the sake of comparison and further inferences, he notices the secretion in other classes of animals, laying emphasis on the proposition, that the quality of the secretion in each is more regulated by the structure of the urinary organs than by any other circumstance, and that the quality of the food, whether animal or vegetable, neither exercises an influence on the quantity of the nitrogenous excretion nor on its kind. He points out how, irrespective of the nature of the food, urea is the chief ingredient of the urine of the Mammalia, and of other animals provided with a urinary bladder; how the alkaline lithates and uric acid take the place of urea in those destitute of this organ, such as birds, serpents, lizards, insects, mollusca, and some lower in the scale of organization, as the myriopoda; and further, how in the instance of scorpions and spiders another compound is substituted for the soluble urea, viz., guanine, which, like the lithates, is excreted in the state of a soft solid.

He concludes with adverting to the harmonious relation of functions in the animal economy, and the close alliance in action between the lungs and the kidneys; adding, that as their activity seems generally to be in accordance, and as in fishes the temperature is low, and little carbonic acid evolved, it may be presumed, as his experiments seem to show, that their urinary secretion is proportionally inconsiderable. And hence, as their digestive powers are great, it may further be inferred that most of their food is assimilated, and is used in administering to their growth. This view he thinks is in agreement with, and helps to explain some of their peculiarities, such as we witness in the salmon, the history of which, of late years, has been so carefully and successfully studied.

2. On the Reproductive Economy of Moths and Bees; being an Account of the Results of Von Siebold's Recent Researches in Parthenogenesis. By Professor Goodsir.

In a recent work, entitled "Wahre Parthenogenesis bei Schmetterlingen und Bienen"—Real Parthenogenesis in Butterflies and Bees, Von Siebold, after reviewing the present condition of the subject, distinguishes the so-called alternate generation from parthenogenesis, and limits Professor Owen's term to reproduction by unimpregnated females.

He has ascertained that this real parthenogenetic mode of reproduction occurs in certain moths—*Solenobia lichenella* and *triquetrella*, the larvæ of which are sac-bearers; and in *Psyche helix*, the larva of which constructs one of those remarkable spiral sacs which have been mistaken for the shells of molluscs.

It would appear that the apterous females of these moths reproduce for many generations without the access of the male, and that the progeny of these virgin females is female.

Von Siebold's observations on the bee larvæ resulted in the verification of the hypothesis recently propounded by Dzierzon, a clergyman and distinguished bee-master in Southern Germany, that *all the eggs which come to maturity in both ovaries of the queen bee are of one kind, which, if deposited without having come in contact with spermatic fluid, are developed into drone or male bees; but if impregnated by spermatic contact, are developed into female,—that is, into working or queen bees, according to their subsequent treatment.* The verification of this remarkable and important physiological doctrine has apparently been effected by, 1, The admitted fact, that working bees occasionally deposit drone eggs; 2, By the determination of the voluntary muscular structure of the spermatheca; 3, By the detection of spermatozoa in the interior of eggs recently deposited in working comb-cells, and the non-detection of spermatozoa in eggs deposited in drone comb-cells; and, 4, By a careful analysis of the entire reproductive economy of the bee.

Von Siebold, therefore, considers himself entitled to conclude that the females of certain lepidoptera, and the males of the bee, are developed from unimpregnated ova.

3. On the Principles of the Stereoscope; and on a new mode of exhibiting Stereoscopic Pictures. By Dr W. Macdonald.

The following Gentleman was admitted an Ordinary Fellow:—

Dr John Ivor Murray, F. R. Coll. Surg. Edin.

The following Donations to the Library were announced:—

Journal of the Asiatic Society of Bengal, No. V. 8vo.—*From the Society.*

Catalogue of Stars near the Ecliptic, observed at Markree during the years 1854-56, and whose places are supposed to be hitherto unpublished. 8vo. Vol. IV. (containing 14,951 stars.)—*From H. M. Government.*

Supplément aux Comptes Rendus Hebdomadaires de Seances de l'Académie des Sciences. Tom. I. 4to.—*From the Academy.*

Mémoires de l'Académie des Sciences de l'Institut Imperial de France. Tom. XXVII. 1re partie. 4to.—*From the Academy.*

Mémoires présentés par divers Savants à l'Académie des Sciences de l'Institut Imperial de France, et imprimes par son ordre. Sciences Mathematiques et Physiques. Tom. XIV. 4to.—*From the Academy.*

Proceedings of the Zoological Society. 8vo. Nos. 310–313. —*From the Society.*

Quarterly Journal of the Chemical Society, No. 36, January 1857. 8vo.—*From the Society.*

Nouveaux Mémoires de la Société Helvetique des Sciences Naturelles. Band XIV. 4to.—*From the Society.*

Mittheilungen der naturforschenden Gesellschaft in Bern, für 1855, 1856. 8vo.—*From the Society.*

Actes de la Société Helvetique des Sciences Naturelles, 1855. 8vo.—*From the Society.*

Verhandlungen der allgemeinen schweizerischen Gesellschaft für die gesammten Naturwissenschaften bei ihrer versammlung

in St Gallen am 24, 25, und 26 Juli 1854. 8vo.—*From the Society.*

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences, May 1856—December 1856.—*From the Academy.*

Monday, 16*th February* 1857.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On the Crania of the Kaffirs and Hottentots, and the Physical and Moral Characteristics of these Races. By Dr Black, F.G.S.

After exhibiting Crania of these races recently received from South Africa, along with two British crania of normal size and form, and stating their respective measurements, facial angles, and principal diameters, the author reviewed the observations of Natural Historians and Anatomists on the skulls and physical characteristics of the races above mentioned. Camper's facial angle was compared with that of Blumenbach, showing the differences, and how far the adult Negro and the orang-outang receded from the higher cranial types; and also how, according to Mr Owen, the facial angle depends upon whether it is taken in the young or adult state. The little difference which exists between the capacities of the skulls of most of the human races was alluded to, and also Mr Owen's opinion of the superiority of the basal examination of the skull over that of the facial angle or vertical aspect. A peculiarity of several Negro skulls was also mentioned, viz., the juncture of the temporal and frontal bones, and consequently the separation of the sphenoid from the parietal. It is observed, that the people of the high countries of Africa are greatly superior to those of the low plains; the former receding further from the physiognomy and colour of the Negro. Colour of skin greatly varies amongst the South African natives, from black to a light brown, even amongst the same nation. The superiority of strength of intellect possessed by the Kaffir over the Hottentot is sufficiently marked; and, on the other hand, is counterbalanced by the greater pliability of dis-

position in the latter, the one being remarkable for reasoning abilities, and the other for aptitude for music, &c.

M. Virey's description of the distinguishing traits of the Kaffirs and Hottentots was noticed, and the mental superiority of the former over the latter. The Kaffirs are held by him, Prichard, and Knox, to be of one ethnic origin with the Negroes, only they are improved, and may be called the Negroes of the mountains, a change being caused by inhabiting an extra-tropical climate.

Dr Morton and the Editors of the "Types of Mankind" were noticed as observing the affinities between the Kaffirs and the Foolahs and Felatahs,—an affinity upon which others have thrown a doubt; while the Editors agree with other observers that the Kaffirs resemble the true Negro much more than the Hottentot, and that the latter is supposed to belong to the same race as the Bosjesman. The great question of the primitive origin of mankind was next adverted to, and it was stated that, in opposition to Dr Prichard, the Editors of the "Types" contend for distinct zoological creations, grounding their opinions partly on Egyptian monuments.

Richard Lander has made personal observations on the Kaffirs, and has shown the resemblance between them and the Felatahs; and Lichtenstein concludes, that the same race of people and the same family of languages were spread into the interior, and also toward the north, far beyond the limits of the Kaffirs proper. Dr Kraff and Peters were quoted, as showing that all the eastern nations, from the equator to the Cape colony, belong to one great family.

The opinion that the Kaffirs ought to be classed with the Europeans or Arabs was shown to be unsound, and also that they considerably recede in features and shape of the skull from the *prognathous* races. There is one trait that directs us to a foreign source, namely, the rite of circumcision, which they universally practise. It is known that the ancient Africans and Egyptians practised the same rite. After noticing the belief of the Kaffirs in a Supreme Being, though they have no idea of future rewards and punishments, the author noticed the Bechuana Kaffirs as superior to the Amakosa, and as having made some advance in arts and civilization, and the Kosah Kaffirs of the pure breed as

approaching in colour and physiognomy to the ordinary Negro, but some of them are of a lighter hue, and redder. Colonel Smith's observations on the Kaffir race are favourable to their intelligence and bravery, and some of them display the peculiar accumulation of fat over the *glutei* muscles which is more common among the Hottentots and Bushmen. He also mentions that the northern tribes try to mitigate the small-pox by inoculating between the eyes. Further testimony seems to establish a near and kindred relation between the languages of South Africa, the idioms of which constitute a particular family of languages, and a singular development of human speech. In one respect these languages are shown to agree with the Coptic—in the law by which they both *prefix* all modifying particles, while other languages *suffix* them.

The author then entered briefly into a description of the Fingoes and Bosjesmen, as given by travellers and natural historians, showing that the latter exhibit the features of the lowest humanity, and are almost allied to the ourang and troglodytes; though Dr Smith's more accurate observations have convinced Dr Prichard that the Bosjesmen are of the same race as the Hottentots, and originally spoke the same language. The oblique foramen at the lower end of the humerus was also noticed as occurring in some of them, as it does in the humeri of the simiæ, dogs, and wild boar. Observations were made on the physical form and features of the Hottentots, including the form of their noses, cheek-bones, chin, eyes, and teeth, their hair and colour, their nipples and mammæ at different ages, and also the *steatopygea* of the females. While some consider them a tribe of Mongolians, and allied to the Kalmucks, others are inclined to think them quite as primitive in their origin as these Asiatics.

The author concludes: "Notwithstanding the difficulties which ethnographists must meet with in assigning a probable origin and descent to the Kaffir, and especially to the Hottentot tribes, sufficient to induce them to resort to the theory of distinct centres of human, as well as of animal and vegetable creation; and, notwithstanding all that has been lately advanced on the subject of the unity of the human species, we may safely say with the eminent Natural Historian, that no differences, such as those observed among mammiferous animals, are to be found among human

families, and that whatever varieties exist in these respects are the effects of external agencies, and the tendency to variation which such agencies call into activity."

2. On a *Roche Moutonneé* on the summit of the range of hills separating Loch Fyne and Loch Awe. In a letter from the Duke of Argyll to Professor Forbes.

Polished and rounded surfaces of rock are, under their more ordinary conditions, of very frequent occurrence in Argyllshire. By "their more ordinary conditions," I mean principally two—viz., Where they occur on the existing coast-line, either at, or not far above the present level of the sea; secondly, Where they occur in valleys, or the lower flanks of the hills,—whether under the boulder clay, or on surfaces naturally exposed.

From the occurrence on Loch Fyne of some beds of a chloritic schist, which is both very soft and very tough, receiving easily mechanical impressions, and resisting as easily the chemical agencies which tend to wear them off, there are on its shores some very fine examples of rocks rounded and deeply grooved. So far as my observation goes, however, they all indicate not only a configuration of the surface identical with that which now exists, but also a comparatively small change in the level of the sea. The prominent points upon the shore are those which are principally marked—the direction indicated is from the head of the loch towards its mouth; that is to say, the direction which ice breaking up from the high mountains at the head of the lake would naturally take in its passage to the open sea. There is nothing to imply a change of level beyond some fifteen or twenty feet.

In the glens leading into Loch Fyne, in the neighbourhood of Inverary, the stones and boulders in the clay are abundantly marked by abrading action. But I have not observed upon the walls of those glens any appearances which would indicate direct glacier action. When smoothed surfaces of rock appear at all, they seem rather connected with the general phenomena of the Boulder Clay. There is one observation, however, which applies generally, if not universally, to smoothed surfaces of rock in all these situations—viz., that the direction of the striæ is that of the glen or valley in which the rock is situated, that is to say, they are in the direction

which currents of water, whether bearing ice or stony matter, or both, would naturally take, if guided in any degree by the existing configuration of the surface.

What appears to me to be the peculiarity of the "Roche Moutonnée" I am now about to describe, is its position, forcing us to seek for its explanation in causes with which the physical geography of the country can have had comparatively little to do.

In a communication to the Geological Society of London which I made about three years ago, with reference to another subject, I gave a general description of the structure of the ridges which separate the valley of Loch Fyne from that of Loch Awe. This line of hills, taken from the point where it is traversed by Glenaray, runs in a south-westerly direction about twenty miles, till it falls into the transverse valley behind Lochgilphead, along which the Crinan Canal is carried from Loch Fyne to the Western Sea. It is of moderate elevation as compared with the great group of mountains which lies to the N.E. But these mountains, closing round the upper end of Loch Awe, terminate in Ben Cruachan, opposite to the point which I have taken as the commencement of the ridge referred to; and beyond that point the remainder of the northern shores of Loch Awe, and the whole district of country extending from it towards Oban, is of much lower elevation, so that, standing on the higher points of the range of hills to which I refer, there is an uninterrupted view to the channels which wind among the larger Hebrides to the mountains of Jura, Colonsay, Mull, and up the Linnhe Loch to the entrance of the great valley of the Caledonian Canal.

It was on going to one of these points—the highest on the ridge for some miles, and probably about 1800 feet above the level of the sea—during last autumn, that I was surprised to observe close to the summit so remarkable an example of a well-rounded surface of rock as to attract my attention from a considerable distance. It is the more remarkable, from the contrast it presents with the generally sharp and broken edges of the strata, which are there composed of hard quartzose beds, at a high inclination, and with steep escarpments. The direction from which the abrading force has acted is about N.N.E. It has passed over a lower shoulder in its way—lower by about 100 feet; but the effect is strongest upon the rocks of the main peak itself, and especially

upon one or two prominent faces within twenty or thirty feet of the summit. Above this it may be observed sloping off, as it were, with diminished force, over successive ledges towards the top, until it passes close behind the very highest point, leaving that point itself apparently untouched.

I need hardly say, that in this case glacier action is impossible. Even if this hill had itself been the seat of the glacier, it could only have been snow so near the summit.

There is one explanation which immediately suggests itself to the mind, and, however difficult it may be to realize the conditions which it involves, it is the only one which it seems to me to be possible to suggest. It is that this peak, when subject to that grinding force, was a rocky islet just appearing above the surface of a glacial sea, and that floating icebergs, drifting from the north-eastward, were constantly grounding upon its sides. I may observe, that this explanation would accord with the fact that the surfaces displaying most strongly the effects of the abrading action are considerably below the summit; because, as ice floats deep in the water—not more than one-twelfth of its bulk being above the line of flotation—the heaviest masses would always ground upon such a rock at a distance from the top proportioned to the steepness of its declivity, and none but the lighter pieces would ever be drifted over the higher points.

If this peak was ever, as I have supposed, a mere rock just appearing above the level of the sea, it becomes of course necessary to suppose that its altitude above the present level of the ocean is due to subsequent elevation. But as the geological structure of the range—the dip and inclination of its rocks—were clearly the same when it was subject to these forces of a glacial sea, it becomes necessary further to suppose that the required elevation has been a general one, affecting the whole country of which this range forms a part. But if this were so, and whether the elevation was slow and continuous, or more rapid and effected by (as it were) successive heaves, we should expect to find at corresponding points evidences of the same action at lower and lower stages. There is certainly one such evidence, viz., that on some of the lower ridges which fall in successive steps to the shores of Loch Fyne there are some very remarkable examples of large blocks of granite perched upon the very summits, in posi-

tions which it is impossible to suppose them to have attained by any other means than transportation upon ice. Such blocks, if they had fallen or rolled from above, must have crossed deep hollows, and again bounded up steep slopes with such a nice adjustment of impetus as to exhaust itself exactly at the very top, leaving them perched, where perhaps a single step in advance would have precipitated them on another journey into the glen next below. But this position so far from being a difficulty, is but the natural position in which we should expect to find them, if ice had been the transporting agent; because, what are now summits must have been then shoals, upon which ice would ground, and upon which, also, ice melting, they would drop their burdens.

I send with this very short notice, a copy of the paper to which I have referred,* upon the geological structure of the line of hills on which this Roche Moutonnée occurs. In it there is an eye sketch, tolerably correct, taken from Loch Fyne, of the range of hills between its waters and Loch Awe, and I have marked in red ink the point where the smoothed surface occurs. On the succeeding page of the same paper there is an ideal section of the same range of hills, and on this I have likewise marked both the position of the rock and of the massive blocks of stone alluded to in this letter.

Since I came to London, my attention has been drawn by Sir Charles Lyell to a paper, in which he has described a similar phenomena in the United States, and in which he accounts for it by the same explanation. In that case, however, the fact of a Roche Moutonnée on the summit of a range of hills is accompanied by other very peculiar phenomena of transported boulders, which corroborate in a manner not to be mistaken the conclusion thus arrived at. The continuity and uniformity of direction taken by the floating ice in that case, as evidenced by the lines of its deposit, is a peculiarity which must have been due to local causes. But if the facts of submergence and elevation to such an extent be established anywhere, there is no difficulty in applying the same explanation to other cases, which, however different in detail, involve the same essential facts.

* Quarterly Journal of the Geological Society for November 1853.

I need not allude to the questions which crowd upon us in contemplating the explanation thus suggested. What is the connection between the glacial period indicated by the Roches Moutonnées found close to the present level of the sea, and those —in all respects so similar—found on the tops of mountains of such considerable elevation. Was it one long glacial epoch during which the required elevation was accomplished? or was it a recurrence of similar conditions after a gale of intermediate changes?

3. On M. J. Nicklès' claim to be the Discoverer of Fluorine in the Blood. By George Wilson, M.D., F.R.S.E., Regius Professor of Technology in the University of Edinburgh.

I am very reluctant to occupy the time of this meeting with a personal matter, but as I am necessitated to defend my priority in reference to certain researches which, in greater part, were first communicated to this Society, and first made public through its "Transactions," it seems the proper tribunal, at least in this country, to adjudicate on a question liable to dispute.

A communication was made to the French Academy, at its meeting on the 3d of November 1856, by M. J. Nicklès, entitled "Presence du Fluor dans le Sang." From the tenor of M. Nicklès' remarks, it would seem that he is not aware that the existence of fluorine in the blood was announced by me in 1846, and specially demonstrated in 1850; nor is he acquainted with the researches which others besides myself have made in this country and in America, into the distribution of fluorine throughout the different kingdoms of nature. In justice, accordingly, to all parties, I seek to recal the following facts, which may save M. Nicklès needless labour, and prevent future disputes. His announcement is as follows: It is reported in the *Comptes Rendus* for November 6, 1856, and in the *Journal de Pharmacie et de Chimie*, December 1856, p. 406, from which I take it:—

"*Présence du Fluor dans le Sang.* Par M. J. Nicklès. (Communiqué à l'Académie des Sciences, dans la séance du 3 Novembre 1856.)

"Par suite de considérations que j'aurai prochainement l'honneur de

soumettre à l'Académie j'ai été conduit à vérifier cette assertion tant contestée, de la présence de fluor dans les os. Mes expériences ayant été affirmatives j'ai recherché le fluor dans le sang, seule voie par où il ait pu arriver jusqu'au tissu osseux. J'y en ai trouvé de notables proportions, non pas seulement dans le sang humain, mais encore dans celui de plusieurs mammifères (porc, mouton, bœuf, chien), et de plusieurs oiseaux (dindon, oie, canard, poulet).

"Des résultats si concordants me semblent donner au fluor une importance qu'il n'a pas eue jusqu'à ce jour en médecine ou en physiologie; ils infirment évidemment cette opinion de Berzélius, suivant laquelle la présence du fluor dans les os est purement accidentelle, et qu'en tout cas elle n'est pas nécessaire.

"S'il fallait d'autres preuves en faveur de la nécessité de reviser le jugement de l'illustre chimiste, on le trouverait dans les faits suivants: il y a du fluor dans le bile, il y en a dans l'albumine de l'œuf, il y a dans la gélatine, il y en a dans la salive, dans l'urine, dans les cheveux; il y en a dans les poils d'animaux (bœuf, vache, et veau); en un mot, l'organisme est pénétré de fluor; on peut s'attendre à en trouver dans tous les liquides qui l'imprègnent.

"Dans un prochain travail je ferai connaître les procédés très simples à l'aide desquels j'ai pu reconnaître la présence du fluor dans toutes ces matières. Pour le moment, je dois me borner à prendre date et à prier l'Académie de me donner acte de cette communication."

I subjoin, for convenience of reference, an English translation:—

"From considerations which I shall shortly have the honour to submit to the Academy, I have been led to verify the much disputed assertion of the presence of fluorine in the bones. My experiments having been affirmative, I sought for fluorine in the blood, the only channel by which it could have reached the osseous tissue; and I found notable quantities of it, not only in human blood, but also in that of several of the Mammalia (pig, sheep, ox, dog); of several birds (turkey, goose, duck, fowl).

"Results so uniform appear to me to give to fluorine an importance which it has not yet obtained in medicine or physiology; they manifestly contradict the opinion of Berzelius, that the presence of fluorine in the bones is purely accidental, and that it is at any rate non-essential.

"If other proofs were needed to show the necessity of revising the judgment of the illustrious chemist, they would be found in the following facts: there is fluorine in the bile, in the albumen of eggs, in the saliva, in the urine, in the hair; in the hairs of animals (ox, cow, calf); in a word, the organism is penetrated by fluorine, and we may expect to find some in all the liquids with which it is impregnated.

In an early work I shall make known the very simple processes by means of which I have recognised the presence of fluorine in all those

substances. For the present I limit myself to noting the date, and asking the Academy to give me formal acknowledgment of this communication."

From the statement of Nicklès, which I have quoted in full, it will be seen that its author was led by his verification of the conclusion, first announced at Rome by Morichini and Gay-Lussac in 1802, that fluorine occurs in the bones of animals, to infer that it must be conveyed to these organs by the blood, and to seek for it in that fluid.

The majority of analysts, however, have long ago justified the early Roman observations. In particular the question of the presence of fluorine in bones was keenly contested in London in 1843, and analyses confirmatory of its occurrence in them were published by Professor Daubeny and Mr Middleton; to which in 1846 I added, in a communication made to this Society, the accordant results obtained by Professor Gregory and myself, and drew attention to the suggestion of Professor Graham of London, and of Dana, the American geologist, that animals possibly derived the fluorine found in their tissues from fluoride of calcium held in solution by water containing carbonic acid. In the same paper I adverted to the conclusion of Mr Middleton, founded on his detection of fluorine in a multitude of aqueous deposits, that "beyond a doubt it is present in water, though perhaps in very minute quantity. . . . . The simple fact that the blood conveys it to the bones would, I apprehend, sufficiently confute any scepticism on the subject."

At this point I took up the inquiry in January 1846, and on April 6 of that year communicated a paper to this Society, in the "Transactions" of which it was published. It will be sufficient here to give an epitome of its contents. The paper was entitled "On the Solubility of Fluoride of Calcium in Water, and its relation to the occurrence of Fluorine in Minerals, and in Recent and Fossil Plants and Animals." It is divided into seven sections. The first, entitled "Introductory Remarks," details the researches of my predecessors, including those to which I have just referred. The second, entitled "Of the Solubility of Fluoride of Calcium in Water," points out, that, contrary to previous belief, this salt is dissolved by pure water, yielding a solution answering to all the tests of lime and of hydrofluoric acid. The third, entitled "Of the presence of Fluorine in Well, River, and Sea Water," confirms and extends the observa-

tions of previous analysts on the occurrence of a dissolved fluoride in fresh water, and for the first time announces its direct discovery in sea-water, where Middleton and Dana had independently anticipated its presence, after finding it invariably in the shells of marine mollusca and in corals. The fourth section, entitled "Of the presence of Fluorine in Minerals," does not call for special notice. The fifth entitled "Of the presence of Fluorine in Plants," confirms the results of Will of Giessen as to the existence of this element in the ashes of vegetables, and draws attention to plants and to water as the media by which fluorides may be transferred from the soil to animals. The sixth section, entitled "Of the presence of Fluorine in Animals," commences with the statement, "As there exists, then, a twofold source of fluorine for animals, we may anticipate its occurrence in various parts of their structure;" and thereafter announces, in opposition to the negative results of Dr Rees, my confirmation of the observation of Berzelius, that a fluoride is present in human urine,—a result which the great Swedish chemist hailed with satisfaction before his death*, although M. Nicklès seems to think that he has been the first to confirm the original assertion. The paper then proceeds to state,—"It could not be doubted, after the facts I have detailed, that fluorine would be found in the two great formative liquids of the animal body, blood and milk; I have found it in both. So far as I am aware, it has hitherto been overlooked in all the analyses that have been made of these liquids; probably it has not been sought for. I employed the blood of the ox, and in two cases obtained markings on glass which only became visible when breathed upon, but are then quite manifest. In the third, the glass was distinctly, though faintly, corroded."

The concluding part of this section is occupied with a criticism of the declaration of Treviranus, that the gastric juice of birds contains hydrofluoric acid; the final sentence being, "We may now look for fluorine in all the animal fluids."

I merely name the title of the seventh section, which is headed "Of the presence of Fluorine in Fossil Bones, and its relation to Animal Life."

In the summer of the same year, 1846, I ascertained the extent to which pure water dissolves fluor-spar, namely, 0·26 grains

* *Jahres-Bericht*, von Jacob Berzelius, 1848, p. 164, which contains a general comment on my researches of 1846.

in 7000 grains of the liquid at 60° F. This result was announced to the British Association at its meeting for that year, and to this Society in November. In 1849 these observations were repeated with certain variations, to meet objections which had been raised to my conclusions, but with the same result. In 1849 I communicated to the British Association the results of a series of analyses, demonstrating by a new method of inquiry the presence of fluorine in the waters of the Frith of Forth, the Frith of Clyde, and the German Ocean; and in March 1850 I communicated to this Society an additional series of observations made in the same way, but extended to the waters of the Irish Sea, of the Atlantic, and the Mediterranean. This paper was accompanied by a letter from Professor Forchammer of Copenhagen, testifying to the presence of fluorine in the waters of the Baltic. In the summer of the same year (1850) I returned to the analysis of blood and milk for fluorine, feeling assured that still more decisive proofs of its presence in both could be obtained by using a larger amount of material, and subjecting it to a simpler process. Accordingly, employing in the case of blood (which was that of the ox) 26 imperial pints, in the case of milk 9 imperial pints, and in that of cheese 12 lbs., I was able to etch glasses with the hydrofluoric acid evolved from them so deeply that they might have been printed from, like copper plates. The etched glasses were shown to the members of the Chemical and Physiological Sections of the British Association, at its meeting in Edinburgh in 1850, and the details of the process published in its "Transactions," as well as in the Edinburgh Philosophical Journal for October of that year.* In the spring of 1852, I again brought the subject before this Society in a paper entitled "On two new Processes for the Detection of Fluorine when accompanied by Silica; and on the presence of Fluorine in Granite, Trap, and other Igneous Rocks, and in the Ashes of Recent and Fossil Plants." (Read April 19, 1852.) In the summer also of the same year, a communication, founded on an application of these processes, was made to the Botanical Society of Edinburgh,—"On the presence of Fluorine in the stems of Gramineæ, Equisetaceæ, and other Plants, with observations on the sources from which vegetables derive this element." In this com-

* They are specially referred to in the English translation of Lehmann's "Physiological Chemistry," by Prof. G. E. Day, vol. i., p. 425. Cav. Soc. Publ. 1851.

munication, read July 8, 1852, I reported the results of an examination of twenty-four plants or vegetable products, in twelve of which fluorine was found. It will suffice to state in reference to both papers, that their object is to point out, and illustrate by examples, methods of readily discovering fluorine in circumstances which previously rendered its detection difficult.

The more perfect of the two processes has been applied with success by Professor Hoffmann to the detection of fluorine in the mineral waters of Harrogate; and Fresenius has introduced it into the last edition of his "Qualitative Analysis."*

The researches thus referred to have been chiefly published in the "Transactions" of this Society, and of the British Association, but have been brought in part before the Chemical Society of London. They are known in Germany, Denmark, Sweden, and America, and have been referred to by many authors in this country. It is reasonable, accordingly, to infer that some knowledge of them has reached Paris; and it might have been supposed that they had not altogether escaped the notice of M. Nicklès, whose name appears on the title-page of the *Journal de Pharmacie et de Chimie*, as editing the department of that work entitled "Une revue des Travaux Chimiques publiés à l'Etranger."

I bring no charge, however, against M. Nicklès. In these days of multiplied monographs it would be unjust to blame any man for ignorance of a single series of special researches. Nevertheless, seeing that this author's name appears on the title-page of the *Journal de Pharmacie* side by side with those of our Vice-President Dr Christison, as its Edinburgh Correspondent, and of Dr Redwood, the Secretary of the Cavendish Society, as its London Correspondent, the countrymen of M. Nicklès, may think themselves entitled to quote the legal maxim, "de non apparentibus et de non existentibus eadem

* Fourth edition of the English translation, 1855, p. 134, stated by its editor, Mr J. L. Bullock, to correspond with the eighth German edition. The process essentially consists in heating the silicated fluoride with oil of vitriol, and condensing the gaseous fluoride of silicon in aqueous ammonia, which after evaporation, re-solution in water, and desiccation, yields fluoride of ammonium. Fresenius recommends the addition of "some coarse pieces of marble to insure a continuous slight evolution of gas;" but I cannot approve of this recommendation, since the constant occurence of fluorine in shells and corals implies its presence in limestones; and the employment of marble for the purpose indicated risks the introduction of the very element for which we are seeking.

ratio," and to infer that what of reputed English science is not known to him, does not exist to be known. Whilst, therefore, I wish M. Nicklès all success in extending our knowledge of the organismal distribution of fluorine, I ask from him, now that he is made aware of the fact, acknowledgment of my priority in reference to the discovery which he specially claims, and of the other discoveries which the papers referred to announce.

The following Gentlemen were admitted Ordinary Fellows :—

Right Hon. John Melville, Lord Provost.
John Blackwood, Esq., 3 Randolph Crescent.
Brinsley de Courcy Nixon, Esq., London.

The following Donations to the Library were announced :—

Monograph of the genus Abrothallus. By W. Lauder Lindsay, M.D., 8vo.—*From the Author.*

Reports of the Meetings of the Royal Institute of British Architects.—*From the Institute.*

Meteorological Observations taken during the years 1829 to 1852, at the Ordnance Survey Office, Phœnix Park, Dublin; to which is added a series of similar observations made at the principal trigonometrical stations, &c., in Ireland. Edited by Capt. Cameron, R.E.; Lieut.-Col. H. James, R.E., Superintendent of Survey, 4to.—*From the Right Hon. The Secretary of State for War.*

Proceedings of the Royal Astronomical Society, XVII., No. 23, 8vo.—*From the Society.*

Memoires de la Société Impériale des Sciences Naturelles de Cherbourg. Vol. III. (1855) 8vo.—*From the Society.*

British Interests in the Canalization of the Isthmus of Suez. 8vo. —*From the Author.*

Papers read at the Royal Institute of British Architects, January 1857. 4to.—*From the Institute.*

Tables showing the number of Criminal Offenders in England and Wales in the year 1855. Folio.—*From the Right Hon. the Secretary of State.*

Instructions for making Meteorological Observations.—*From the Scottish Meteorological Society.*

Monthly Returns of the Births, Deaths, and Marriages, registered in the eight principal towns of Scotland; with the causes of death at four periods of life.—*From the Registrar-General.*

Quarterly Returns of the Births, Deaths, and Marriages, registered in the Divisions, Counties, and Districts of Scotland.—*From the Registrar-General.*

Monday, March 2, 1857.

The Right Rev. BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read:—

1. On the Functions of the Spinal Cord. By Professor Hughes Bennett.

The object of Dr Bennett's communication was to unite two separate kinds of research, which of late had been directed towards advancing our knowledge of the structure and functions of the spinal cord. From these it would, he thought, appear, that the views considered to be so firmly established by the genius and labours of Charles Bell, required great modification. Dr Bennett then gave a sketch of these views, and of the present opinions of physiologists regarding the functions of the spinal cord. He indicated certain facts which had long been recognised as difficult of explanation in accordance with them. He then described the results of several experiments by M. Brown-Séquard on the columns of the cord in living animals, which he himself (Dr B.) had witnessed, and which satisfied him that, on the posterior columns being cut across, increase of sensibility in the inferior extremities was the consequence, instead of paralysis. He also described the discoveries recently made in the structure of the spinal cord, by Budge, Kölliker, Lockhart Clarke, Stilling, Remack, Wagner, Van der Kolk, Schiling, Kupffner, and especially by Owsjannikow. He pointed out how the structural discoveries threw light on the experimental ones, and from the whole inquiry drew the following conclusions:—

1. Although the anterior and posterior roots of the spinal nerves may still be considered motor and sensitive, we can no longer apply these terms to the anterior and posterior columns of the cord.

2. The fibres in these columns do not convey impressions directly and continuously to the brain as hitherto supposed, but enter the grey matter, and operate through the ganglionic cells of that matter.

3. That all so-called reflex movements are carried on by a definite system of conducting fibres and ganglionic cells, passing through the grey matter; in other words, they are *diastaltic* and not reflex.

4. That the particular fibres and cells which are necessary to spinal diastaltic acts have yet to be discovered; so that a new field of inquiry is opened up to the physiological histologist.

2. On the Delta of the Irrawaddy. By T. Login, C.E., Pegu. Communicated by William Swan, Esq.

Little is known of the course of the Irrawaddy River above Ava, and as it is joined by no large tributary near its mouth, its sectional area differs very little for hundreds of miles. At Prome, a distance of 190 miles in a direct line from the sea, the river is confined between two ranges of hills. The eastern range passes through the Tharawaddy district, separates the Irrawaddy from the Sittang Valley, and is lost in low undulating hills at Rangoon. The western or Aracan range is more mountainous, and terminates in a bluff headland forming the right bank of the Bassein River at its mouth. The plain bounded by these two ranges is inundated when the river is in flood—so much so, that it can be traversed in almost any direction in small canoes.

The Irrawaddy, like all other large rivers in India, begins to rise in March, and attains its highest elevation in August, after which it gradually subsides, until it is again swollen by the melting of the snows among the hills, when it rises from 10 to 12 feet before the setting in of the rains.

My observations were made at Than-ba-ya-doing in March 1855, with as great care as circumstances would permit, to determine the discharge, velocity, slope, and the proportions of earthy matter suspended in the water. It was found that, when the river was at its lowest, it discharged 75,000 cubic feet per second. The mean surface velocity was $1\frac{1}{2}$ miles in the hour, the slope $1\frac{3}{8}$ inches in the mile, and the proportion of earthy matter was $\frac{1}{5735}$ by weight.

When the river is in flood its surface rises 37 feet higher than in the dry season; the discharge was estimated at 750,000 cubic feet in the second, with a surface velocity of 5 miles in the hour, a slope of $3\frac{1}{6}$ inches in the mile, and the proportion of silt about $\frac{1}{1700}$ by weight.

Although, however, I had thus obtained the extreme cases approximately, I had no means of determining the average discharge for the 12 months; but for my present purpose, I have supposed it to be 350,000 cubic feet per second, containing $\frac{1}{3000}$ part by weight of earthy matter; and as the clay of the delta is nearly twice the specific gravity of water, there would be 60 cubic feet of silt passing Than-ba-ya-doing every second, to form the delta; or say 2,000,000,000 cubic feet annually.

The apex of the delta, and the mouths of the Rangoon and Bassein Rivers, are each about 140 miles apart, which would give an area of 8500 square miles; but as the delta is intersected by creeks, the dry land may be 7500 square miles. For the sake of calculation, I have supposed the silt to be evenly deposited to a distance of 25 miles out at sea off the mouths of the river, and that each annual stratum is five times the thickness of the deposits on the dry land of the delta. By the above approximate data, which I trust will be found hereafter to differ not very widely from the truth, the following is obtained:—

$$\left(140 \times 25 + \frac{7500}{5}\right) \times (5280)^2 = 139,392,000,000 \text{ square feet};$$

or say an area of 140,000,000,000 square feet to be covered by 2,000,000,000 cubic feet of silt: thus, each cubic foot would have to cover 70 square feet at sea, and 350 square feet on the delta, or the sea would become $\frac{1}{6}$th of an inch shallower every year, and the land would be raised $\frac{1}{30}$th of an inch. The delta, however, must be 6 feet higher at the Rangoon mouth of the river than at the Bassein mouth, as the tide rises 21 feet at the former point and only 9 feet at the latter. Again, as correctly as I could learn, the tidal wave is not sensibly felt higher up than 35 miles below Than-ba-ya-doing in the dry season; and, in the rains, it only reaches a point 95 miles lower down, as measured along the course of the stream. I could thus approximately find the level of Than-ba-ya-doing to be 40 feet above high tide, and the slope of the river $3\frac{1}{6}$ inches.

Supposing, therefore, my calculations to be correct, and not taking into account the effects of vegetation, it must have taken 14,400 years to raise the head of the delta above high tide to its present level. If to this be added the probable time it took to raise the beds of the ocean above high water, even with such a powerful agent at work as the Irrawaddy, ages on ages must have elapsed since this silting up process began. From the great depths of the river, and its liability to change its course, relics of man, and bones of existing animals, may hereafter be found even more than 100 feet below the sea, at different points throughout the delta. Caution should therefore be observed in ascribing antiquity to such relics, nor should they be considered a proof of the subsidence of the land.

Before commencing this survey, Lieutenant Walker of the Bengal Engineers pointed out to me the inaccuracy of M. Du Buat's rule for calculating the discharge of rivers. I also, while engaged on the survey, discovered that the fundamental rule for finding the mean and bottom velocities, by the known surface velocity, was also inaccurate. The rule is, where the surface velocity v is expressed in inches, the bottom velocity equals $(\sqrt{v}-1)^2$.

But even when the river was at its lowest, the bed, which consisted of sand, could only have withstood half the velocity calculated by this rule; and when the river was in flood, even large boulders would have been swept along by the current. To this fact I beg to draw particular attention, for at no point did I find the bed to consist of such materials as could withstand the calculated velocity; but the nature of the bed always varied according to the *depth* and surface velocity. I therefore estimated the bottom velocity by the nature of the bed, instead of abiding by the above rule, and found the mean velocity, by halving the sum of the estimated bottom and known surface velocities. Mr Ellet, however, found on the Mississippi, that where the river was deep, the velocity was always greater at some depth below the surface than at the surface itself.

Another source of error,—the one of all others most difficult for the engineer to contend against,—is the power rivers have of abrading their beds to considerable depths, and again silting them up to their former level while the flood is subsiding.

I have had many opportunities of observing this process of scooping out the bed and again silting it up, and I have known it to

extend to a depth of ten and a-half feet in rear of one of the works on the Ganges Canal that was under my orders.

In the accompanying table I have compared the Irrawaddy with a few of the largest rivers. (P. 476.)

The discharge of the Ganges appears to me much too small; for I have seen both the Nile and the Ganges in flood, and should say that the Ganges at Gazepoor is nearly three times the size of the Nile. The proportions of earthy matter vary to a great extent in all the above-mentioned rivers. The Ganges appears to convey the largest proportion of silt and the Rhine the least.

The power of a river in transporting earthy matter, however, chiefly depends on the *shape* of the particles: sand, which is only one-seventh the specific gravity of gold, will sink much faster in water than gold leaf. By investigating this branch of the subject, the power of water in motion to transport solid bodies may be discovered, as the rate of sinking of any solid body must bear some proportion to the velocity of the water required to transport that body. It may here be also remarked, that where there is a strong current in the ocean, rivers cannot push out deltas into the sea; and rivers which fall into tideless seas have no trumpet-shaped mouths, nor are they easily navigated, for even the Mississippi has only fourteen feet water at its mouth, though it is 170 feet deep higher up the river, and the bar consists of soft mud.

As a navigable stream the Irrawaddy is second to few rivers in the world; for not only are its mouths easily approached, but for hundreds of miles up its course it has been found much more navigable than the Ganges. The valley through which this noble river flows equals, if it does not surpass Bengal in the richness of its soil; can it be doubted, therefore, but that ere long Anglo-Saxon enterprise, and civilization, will force its way into the interior of this rich country?

P.S.—On this paper being read, Professor Forbes drew the attention of the Society to that part which related to the abrading power of water at different velocities; he stated that the experiments referred to were made fifty years ago by Professor Robison, his predecessor; and as the subject was of considerable interest, he hoped some one would verify these experiments.

Through his kindness in giving me the use of some of his instru-

ments and class-room, along with the assistance of one of his establishment, I am enabled to give the few following results of experiments tried on brick-clay from Portobello, sea and fresh-water sand, rounded pebbles about the size of peas, and common vegetable soil.

1. The brick clay, in its natural moist state, had a specific gravity of 2·05; and water passing over it for half an hour at a rate of 128 feet in the minute, which was the greatest velocity I could conveniently obtain, made no visible impression on the clay. When this clay was mixed with water, and allowed to settle for half an hour, it required a velocity of fifteen feet in the minute to disturb it. This mud sank in water at a rate of 0·566 feet in one minute, but the very fine particles were very much longer in subsiding.

2. The fresh-water sand, which sank in water at an average rate of 10 feet in the minute, required a velocity of 40 feet in the minute over the bed to disturb it.

3. The sea-sand sank 11·707 feet in one minute, and was moved over the bed by a velocity of 66·22 feet per minute.

4. The rounded pebbles, about the size of peas, which sank at the rate of 60 feet in one minute, were rolled over each other by a velocity of 120 feet in one minute.

5. The vegetable soil, being a mixture of different kinds of particles, it was difficult to determine the rate of sinking. The very fine particles were swept away by a velocity of 2·45 feet in the minute, and those that were disturbed by a velocity of 33⅓ feet in the minute, sank at a rate of 0·98 feet per minute only. All the vegetable soil was swept away when the velocity of the water over the bed was increased to 50 feet in the minute, and the particles of sand left, of which nearly one-half of this soil consisted, were set in motion by this velocity. This sand, however, only sank at a rate of 5·62 feet in one minute.

From the above it is evident that the velocity of water over the beds of canals, and water-courses for irrigation, unless protected by a pebbly bed, should never exceed half-a-mile an hour, otherwise the fields irrigated will be covered with a stratum of sand.

These experiments were made with water seldom exceeding half an inch in depth, and the float was within ¼ or ⅛ of an inch of the bottom. The time was measured by an instrument which indicated tenths of seconds.

Comparison of the Irrawaddy with other large Rivers.

Name of River.	Discharge per second in cubic feet.			Proportions of Silt by weight.			Slope per Mile in Inches.	Surface velocity in Miles per hour.		
	Greatest.	Least.	Mean.	Largest	Smallest.	Mean.		In Flood.	In Dry Season.	
Irrawaddy, .	750,000	75,000	350,000	$\frac{1}{1700}$	$\frac{1}{5725}$	$\frac{1}{3000}$	3·80	$3\frac{1}{2}$ to 5	$1\frac{1}{2}$	Mr Login.
Mississippi, .	1,700,000	...	385,000	$\frac{1}{593}$	$\frac{1}{2810}$	$\frac{1}{1155}$	3·25	5 to 7	...	Mr Ellet.
Ganges at Gazepoor, .	494,208	36,330	207,000	...	...	$\frac{1}{428}$	4·00	4 to 7	...	The Rev. Mr Everest.
Burrumpooter,	...	150,000	...	...	...	...	...	...	...	Measured in January by Major Wilcox.
Nile, . . .	333,394	214,621	101,000	...	...	$\frac{1}{633}$	5 to $5\frac{1}{2}$	$3\frac{3}{4}$	$1\frac{3}{4}$	Mr Horner.
Rhine at Bonn,	...	...	66,000	$\frac{1}{12600}$	$\frac{1}{2078}$	$\frac{1}{16340}$	...	...	...	Ditto.
Amazon, . .	...	...	...	...	...	...	2·35	$3\frac{1}{2}$	...	

3. Notice of a Collection of Maps. By A. K. Johnston, Esq.

In this paper the author reported the progress made by the committee appointed to select and purchase a series of chartagraphic works for the library of the Royal Society, and the means adopted for their arrangement and classification. The collection already comprises 534 separate sheets of the best existing maps, chiefly of the several countries of Europe, but embracing the survey of India, in so far as published. The maps are placed in cases resembling volumes, so indexed as to admit of being indefinitely extended, and easily consulted. Specimens of the different works were exhibited, and the author presented a rapid sketch of the progress of surveying and mapping, from the sixteenth century to the present time. He showed that modern improvement in this important branch of science dates from the middle of the 18th century, when, in 1750, Cassini de Thury, under the auspices of the French Academy of Sciences, constructed a map of France on astronomical principles. In 1784 the French triangulation was extended to London, and formed the basis of the trigonometrical survey of Great Britain. The surveys of Belgium, the Netherlands, Prussia, and Sardinia, have also been based on that of France. The different methods adopted to represent relief of the surface by contour lines and hill shading, were then referred to, and examples of the effects produced by vertical and oblique lights were exhibited. It was shown that the method which supposes the light to fall vertically on the model, casting the shadow in all directions, gives the most exact idea of the inequalities of the ground, and that it is adopted in nearly all the great survey maps now in progress. As an example of the time and labour necessary to produce a good map, it was explained that in the great survey of France, now nearly completed, a single sheet requires, for reduction and drawing, at least two years, and for engraving, five to eight years. Thus, between the termination of the field-work of the surveyor and the publication, seven to ten years must necessarily elapse. Mr Keith Johnston concluded his remarks by referring to the economical advantages of the electrotype process in reproducing copies of original plates, thus reducing the price of the publication; and to an ingenious application of this process, recently adopted at the Depôt de la Guerre, Paris, by which erasures made in the work, for correction, are filled up by a fresh deposit of copper, leaving a surface ready for being re-engraved.

COLLECTION OF MAPS IN CASES.

EUROPE.

Title.	Author.	Sheets.
Europe (Geological), . . .	Murchison, . .	4
British Isles (Geological), . .	Knipe, . . .	4
England and Wales (Geological),	Government Survey,	104*
Ireland, ...	Ordnance Office, .	6
England and Wales, Topographical, ...	Ordnance Survey,	65*
Scandinavia, ...	Forsell, . . .	9
N. Deutschland, ...	Englehardt, . .	24
Deutschland, Belg., Schweiz, .	Stieler, . . .	25
Königreich Sachsen, ...	State Survey, .	15*
Kurhessen (Geological), . .	Schwarzenberg, .	1
Thüringer Waldes (Geological),	Credner, . . .	4
Salzburg, ...	General Staab, .	1
Würtemberg, ...	Bach, ...	5
Belgique (La) (Geological), . .	Dumont, . . .	10
France (Topographical), . . .	Etat-Major, . .	14*
France (Geological), . . .	E. de Beaumont,	6
Schweiz, Topographical, . .	Dufour, . . .	17*
Suisse (Geological), ...	Studer, . . .	4
Russie d'Europe, ...	Dep. de la Guerre,	29*
Oesterreichische Kaiserthum, .	Fallon, . . .	9
Lombardo-Veneto (Regno), .	Austr. Survey, .	4
Stati di S. M. Sarda, . . .	Survey, . . .	6
Environs de Rome, ...	Dep. de la Guerre,	1*
Alpes, Piemont, Savoye, &c., .	Raymond, . . .	13
Stato Pontificio e G. D. Toscana,	Austr. Survey, .	52
Mont Blanc, ...	Raymond, . . .	1
Kaukasischen Isthmus, . . .	Koch, ...	4
Türkischen Reiches in Eur., .	Kiepert, . . .	4
Thrace, ...	Viquesnel, . .	1
Grêce, ...	Dep. de la Guerre,	20
Islande, ...	Olsen, ...	4

ASIA.

India, (Geological), ...	Greenough, . . .	12
India, E. I. C., ...	Government Survey, .	51*
Klein Asien, ...	Kiepert, ...	16

Those marked with an asterisk thus, * are incomplete, the works being only in progress.

Collection of Maps and Charts.—Continued.

Pilote Française. Dépôt Général de la Marine. 12 tomes.

Third part of the General Survey of England and Wales, containing Cornwall. By Colonel Mudge. (Ordnance.)

The National Atlas of Historical, Commercial, and Political Geography. By A. Keith Johnston, F.R.S.E., F.R.G.S., &c.

The Physical Atlas of Natural Phenomena. By A. Keith Johnston, F.R.S.E., F.R.G.S., &c.

A Geological Map of Scotland. (On roller.) By Dr M'Culloch, F.R.S.

Ordnance Survey of Ireland; scale, six inches to a mile. Twenty-four volumes.

Geological Map of England and Wales. (On roller) By G. B. Greenough.

Atlas, containing Maps of Poland, exhibiting the political changes from 1772 to 1837. By J. M. Bansemer and P. F. Zaleski.

Charts, &c., published by the Hydrographic Office of the Admiralty, London. These are arranged in trays, in the Museum.

The Counties of Perth and Clackmannan. (On roller.) By James Stobie. 1805.

Various Sailing Charts, &c., of the United States.

The following Gentlemen were elected Ordinary Fellows:—

Andrew Murray, Esq. of Conland, W.S.
Rev. Dr Macfarlane, Duddingston.
Dr W. M. Buchanan, E.I.C.S.

Monday, March 16, 1857.

Dr CHRISTISON, V.P., in the Chair.

The following Communications were read :—

1. Notice respecting Father Secchi's Statical Barometer, and on the Origin of the Cathetometer. By Professor Forbes.

A friend, who returned lately from Rome, has sent me some copies of a pamphlet by Father Secchi of the Collegio Romano, one of which I lay on the table of the Society.

It describes a barometer stated to be on a new construction. The barometric tube is suspended from one arm of a balance, and counterpoised. It is filled with mercury in the usual way; but the cistern into which it opens is fixed apart, and does not move with the beam of the balance. It is evident, therefore, that the varying pressure of the air on the exterior of the tube will require a changing counterpoise, and that the magnitude of the change may be increased by enlarging the section of the tube, so that the alteration of pressure may be indicated with any required delicacy.

It is also obvious that, to use this barometer, the tube does not require to be transparent, but may, for instance, be made of iron; only the internal section must be uniform throughout the range of pressure.

The idea of thus measuring barometric pressures appears so obvious that it is not likely to be really new. But I had also, when I read the paper, a distinct recollection of having seen it described many years ago.

After a slight search I found it, accordingly, under the name of the *Steelyard Barometer* (the tube being suspended from the shorter arm of a steelyard, while the other points to the angular deviation on a scale), in Rees, and others of the older Encyclopædias (as in the earlier editions of the *Britannica*), in *Hutton's Mathematical Dictionary*, and in *Gehler's Wörterbuch*. But, what is singular, no inventor is assigned to the contrivance, except in the last-named work, where it is described generally as Morland's; though Hutton, who is there cited as the authority, says nothing of it.

In *Desagulier's Natural Philosophy* (1763), an experiment with a balance, similar to Father Secchi's arrangement, is described and figured, but it is not referred to as a construction available for practical purposes. This might lead one to believe that the contrivance was more recent than Desagulier's time. But, after considerable search, I found, in the nineteenth volume of *Rozier's Observations de Physique* (1782), page 346, a curious historical statement by Magellan, which refers the contrivance to Sir Samuel Morland, who, it is there stated, presented it to Charles II. Magellan does not, however, give his authority for this, stating, on the contrary, that he found no mention of the contrivance in any of the authors who had treated of the subject, but that he had seen two of these instruments. One of them, made by Adams in 1760, belonged to George III.; and I think it possible that it may still be found amongst the instruments of the Kew Observatory. The other was made by the celebrated Sisson, and came into M. Magellan's possession; a careful figure of it is given in the work just cited. It is perhaps likely that the ascription of it to Morland, and the story of its presentation to Charles II., was a tradition among the London instrument-makers. It may, however, be recorded in some of Sir Samuel Morland's writings, which I have not found either in the College or the Advocates' Library, and in which it does not appear that Magellan had himself seen it.

I have as yet been unable to trace the steelyard modification of the statical barometer to its origin. I think it likely to be an independent invention.

Of course these remarks are not intended to infer the smallest doubt on Father Secchi being the inventor of the instrument which he describes. Of that there can be no question; and the application of it, which Father Secchi proposes, to the purposes of self-registration, makes it a well-timed resuscitation of an almost forgotten contrivance, which yet appears to date from the same century with the invention of the barometer.

2d March 1857.

Postscript—16*th March* 1857.—I have not succeeded in throwing any further light on the true origin of the statical barometer. On writing to Mr Welsh of the Kew Observatory, I find that King George III.'s curious collection of apparatus has been long dispersed.

I ought perhaps to add, with reference to Father Secchi's contrivance, that he recommends in some cases the *cistern* of the barometer to be made moveable, instead of the tube. The balance is then disturbed by the efflux of mercury from the tube of the barometer when the pressure diminishes, and by its influx when the pressure increases. Though less elegant, as an application of a principle, it has the advantage of making the suspended mass lighter. It will be seen, by a reference to Magellan's account of Sisson's instrument, that the weight was such as to require support on friction-rollers, instead of knife edges.*

Invention of the Cathetometer.—I take this opportunity of adding a historical notice, which has occurred to me whilst making the preceding inquiry. In the twentieth volume of the Philosophical Transactions for 1698, Mr Stephen Gray described a microscope moving on a vertical pillar by means of a micrometer screw, to be used for determining the exact variations of level of a liquid, such as mercury in a barometer or thermometer, and not necessarily connected with the apparatus. This instrument accurately corresponds in most respects with that known to French physicists and instrument-makers under the name of the *Cathetomètre*, which I have never heard ascribed to any inventor in particular, and which, till very lately, has hardly been recognised in this country.

2. History of an Anencephalic Child. By Dr Simpson.

3. On certain Laws observed in the Mutual Action of Sulphuric Acid and Water. By Balfour Stewart, Esq. Communicated by Dr G. Wilson.

The object of this paper was to show that where sulphuric acid combines with water, distinct reference is made to certain definite compounds or hydrates of sulphuric acid.

* Since this paper was read, I have been enabled to carry back the history of the Balance Barometer, or at least of the experiment described by Desaguliers, considerably farther. In Cotes's *Lectures on Hydrostatics*, &c., published by Smith in 1747 (but which were delivered more than forty years previously), the experiment is fully detailed and explained. It is also ascribed to Wallis, as well as an ingenious modification of it well adapted for the lecture table.

April 1857. J. D. F.

The combination of these two liquids is attended with contraction of volume; that is, the volume occupied by the compound is less than the sum of the volumes occupied by its ingredients when uncombined. By means of a simple formula (assuming 1·8485 to be the specific gravity of strong liquid sulphuric acid), we may find what ought to be the specific gravities of the different strengths in Dr Ure's table, were no contraction to take place. By this table we may find the actual specific gravities of such mixtures; and dividing the actual or observed specific gravity by the calculated specific gravity, and deducting unity from the quotient, we have the proportional condensation.

The proportional condensation is greatest for strength 73 of Dr Ure's table, which is the strength of a hydrate composed of one atom of liquid acid and two atoms of water.

But it is not necessary to suppose all the strengths of Dr Ure's table to be formed by mixing together strong liquid acid and water; for, taking a certain strength as our standard, we may suppose all mixtures stronger than it to be formed by mixing it with strong acid, and all mixtures weaker than it to be formed by mixing it with water in certain proportions.

On this hypothesis we shall have different calculated specific gravities, and consequently, different proportional condensations from those obtained when all strengths were viewed as composed of strong acid and water.

It was shown that a great range of standard strengths gives a maximum at 73, as before, while others indicate a maximum between 84 and 85, denoting a hydrate composed of one atom of liquid acid and one of water. These results were made visible by a curve, of which the abcissæ represented strengths, and the ordinates proportional condensations, and it was shown that points of greatest elevation or depression, or more generally peculiarities in the curve, denoted definite compounds of acid and water. By means of such a curve the following hydrates may be indicated, in addition to those already mentioned:—$SO_3HO + 5HO$, $SO_3HO + 7HO$, $SO_3HO + 8HO$, $SO_3HO + 11HO$, $SO_3HO + 12HO$, and $SO_3HO + 15HO$.

Independent experiments were made in order to see how far Dr Ure's observations were reliable; and a remarkable agreement was found for the weaker strengths tried; but in the higher strengths the observations seemed to show a constant error in Dr Ure's results,

which make the specific gravities too low. The following is a list of the strengths tried, and of the corresponding specific gravities observed:—

Strength.	Observed Specific Gravity.
88·6	1·8041
48·0	1·3737
47·5	1·3688
47·0	1·3643
45·8	1·3537
28·0	1·2033
27·0	1·1954
26·6	1·1925
26·0	1·1874
25·0	1·1795
21·0	1·1481
20·0	1·1405
19·0	1·1329

The constant error supposed to pervade Dr Ure's determinations of specific gravities for the higher strengths, was accounted for by supposing that Dr Ure must have operated with two or more different specimens of acid; the error arising in his determination by chemical analysis of the strength of each, and different acids being used for high and low strengths. As an instance of this, taking strength 90 as our standard, the proportional condensations for strengths 68, 67, 66, 65, are respectively ·0426, ·0429, ·0410, ·0411; that for strength 66 being very much less than that for strength 67. This is indicated by an abrupt fall in the curve at that point, after which it goes on slowly rising, just as before its fall.

These experiments confirmed a maximum point corresponding to the hydrate $HO, SO_3 + 15\,HO$, and showed a minimum point corresponding to the hydrate $HO, SO_3 + 6\,HO$.

Allusion was made to Professor Langberg, who, in a report to the British Association for 1847, has described a method of research somewhat similar, but giving negative results. Professor Langberg expresses the specific gravity of an acid, in terms of its strength, by means of an empirical formula, the constants of which he derives from Dr Ure's experiments, and, by means of this formula, he is enabled to exhibit the proportional condensation of any strength (for a given standard) as a function of that strength, so that, equating the first differential coefficient of this function to zero, the resulting equation gives the position of maximum condensation. The points

so determined do not correspond to definite compounds, probably because an empirical formula is used instead of the immediate results of experiment. In conclusion, the author's results were briefly stated thus:—

1. The points of elevation, depression, or peculiarity in the curve of condensation, denote definite compounds, whatever be the standard strength used.

2. The use of varying the standard is simply to render such points more prominent, or, in other words, to convert a point of peculiarity into one of elevation or depression, as the case may be.

The following Donations to the Library were announced:—

First Report of the Committee on Beneficent Institutions (Medical Charities of the Metropolis). 8vo.—*From the Statistical Society of London.*

Journal of the Statistical Society of London. Vol. XX., part 1. 8vo.—*From the Society.*

The Canadian Journal, January 1857.—*From the Canadian Institute.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-naturwissenschaftlichen Classe, Band XX. heft 2 und 3; Band XXI. heft 1 und 2. Philosophisch-Historische Classe, Band XX. heft 2 und 3; Band XXI. heft 1 und 2. Register zu den zweiten 10 Banden. 8vo.—*From the Imperial Academy of Vienna.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften, Wien. Philosophisch-Historische Classe, Siebenter Band. 4to.—*From the Imperial Academy of Vienna.*

Tageblatt der 32 versammlung Deutscher Naturforscher und Arzte in Wien im Jahre 1856. Nos. 1–8. 4to. *From the Imperial Academy of Vienna.*

Publications of the Königlisch Sachsische Gesellschaft der Wissenschaften, Leipzig, viz.:—

Beitrage zur Kenntniss der Gefässkryptogamen, von Wilhelm Hofmeister. 8vo.

Die Urkundlichen quellen zur Geschichte der Universität Leipzig in den ersten 150 jahren ihres bestehens, von Friedrich Zarncke. 8vo.

Elektrische Untersuchungen von W. G. Hankel. Erste Abhandlung, Uber die Messung der Atmosphärischen Elektricität nach absolutem maasse. 8vo.

—*From the Society.*

A General Index to the Philosophical Transactions, from the first to the end of the seventeenth volume. By Paul Henry Maty, M.A., F.R.S. 4to. London, 1787.—*From the University Library, Edinburgh.*

Supplement to the Quarterly Returns of the Births, Deaths, and Marriages registered in the Divisions and Counties of Scotland. Year 1856.—*From the Registrar-General.*

Monday, 6*th April* 1857.

DR CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. On the Structure of Pedicellina. By Prof Allman.

The author maintained that the genus Pedicellina, notwithstanding the circular arrangement of its tentacula, does not properly belong to the infundibulate Polyzoa at all, but is in reality hippocrepian, of which type, however, it presents a remarkable modification. The intestine at first sight appears to terminate within the margin of a orbicular lophophore, and, consequently, within the circle of tentacula, and thus to present a striking exception to the admitted plan of the Polyzoa. It was shown, however, that the anomaly which thus seems to exist was only apparent, for the lophophore, when carefully examined, is found to be constructed on the hippocrepian type, with the tentacula confined to the outer or convex margin, and the arms of the crescent united at their extremities so as to enclose a space, around which the tentacula will then be arranged in an uninterrupted circle, and within which the intestine opens, its termination being thus quite normal, and properly external to the lophophore.

As in the ordinary hippocrepian Polyzoa, so also here the mouth is furnished with an epistome, which, however, is less complete than in the others, and not provided with special muscles; and it is more-

over highly probable that the calyx, which constitutes a universal feature in the ordinary hippocrepian genera, enters here into the composition of the peculiar cup which surrounds the base of the tentacula, and which the author believes has its homology in a permanently inverted portion of the endocyst, united externally to the uninverted endocyst, and internally to the calyx and tentacula.

2. On a Case of Lateral Refraction in the Island of Teneriffe. By Professor C. Piazzi Smyth.

In his astronomical visit to Teneriffe last summer, the author was instructed to inquire into the lateral oscillation of stars, as seen by Baron Von Humboldt in his ascent of the mountain. During a month's residence on the place of the alleged observation no approach to anything of the sort was ever noticed, although a powerful equatorial, with a twelve-foot telescope and high magnifying powers, was employed to detect any irregularity in the motions of the stars. The author concluded, therefore, that the anomalous movements described by Humboldt could not have been produced by any general or cosmical action of the atmosphere, or of light or heat, which astronomers were bound to consider.

3. On Insect Vision and Blind Insects. By Andrew Murray, Esq.

Mr Murray commences with a *resumé* of what is known regarding the growth of eyes in insects, from the first stage in the larva, when many are without eyes, till their exclusion from the chrysalis, when they usually appear well provided with compound eyes. He reviews the nervous system in different species, and gives some details as to those species which live in dark places, and which have small eyes and a less-developed optic nerve, contrary to what one would at first suppose. The next portion of his paper is devoted to explaining his views of the structure of the eye in insects, and its relation to the eye in vertebrate animals. Instead of seeking the homologies of the parts of the eye in the vertebrata in each separate eye tubule, or individual part of the compound eye in insects, as has hitherto been done, he compares it with the entire compound eye. Resting on the microscopic researches of Kölliker, H. Müller

Brucke, Hannover, Helmholtz, Goodsir, and others, into the intimate structure of the retina, he compares its structure with the structure of the compound eye in insects, making the filamentary layer equivalent to what is called by Leydig the retina in insects, the rods and cones in the bacillary layer to the conical bodies in the eye tubules of insects, &c. And he explains the discrepancy between the relative position of this structure in insects and in the vertebrata, on the principle suggested by Brucke and Hannover, and worked out by Goodsir, that the light is reflected back from the choroid or back of the eye in the vertebrate animal, so that the animal is, as it were, looking backwards, and sees objects as reflected in a mirror; while in insects, he assumes that objects impinge directly on their visual sensorium.

The rest of the paper is occupied with an examination of those insects which are destitute of eyes in their perfect state, with particulars relating to their habits and structure, and concludes with the results of his examination of the interior structure of the integument in the *Anophthalmus Bilimekii*, Schm., from which it appears that the interior texture of the thorax is a series of transverse elongate cells, similar to the cells in plants, and which is known to be the usual, if not the universal, structure of the chitonous integument in insects; the same cells are to be seen in the head; but on the ocular spaces where the eyes should have been, and which (in *Anophthalmus*) occupy a large portion of the head, these cells become enlarged, and gradually less transverse, until, towards the middle of the ocular space, some of them have assumed the hexagonal form usually seen in the facets of the compound eye in insects; whence, Mr Murray concluded, that this is possibly an atrophied or abortive eye, and draws conclusions as to the manner of the development of the eye in insects.

Mr Murray also considers the question, whether these insects are sensible of light, and if so, whether it is through this atrophied eye or not? He supposes they are, to a certain extent, sensible of light; but only in the same way as plants or zoophytes, and not through any optical apparatus.

4. On the mode in which Light acts on the Ultimate Nervous Structures of the Eye, and on the relations between Simple and Compound Eyes. By Professor Goodsir.

Since the publication in 1826, of Joh. Müller's *Vergleichende Physiologie des Gesichtssinnes*, Physiologists have admitted three fundamental forms of the organ of vision. 1*st*, The eye-spot, organized for the mere perception of light. 2*d*, The compound eye, in which the picture on the nervous surface is a mosaic. 3*d*, The simple eye, in which the retinal picture is continuous. The difference between the simple and compound eye, as explained by Müller, and since generally admitted, consists in this, that the formation of the picture in the simple eye is the result of the convergence of all the pencils diverging from the visible points of the object on corresponding points of the retina, by means of the crystalline lenticular structure of the organ; while, in the compound eye, the picture is formed by the stopping off, by means of the constituent crystalline columns of the eye, all rays except those which pass in or near the axes of the columns. The extent of surface of any object, and the number of separate parts of such surface, represented on the nervous structure of a compound eye, will vary, therefore, in terms of the distance of the object, the curvature of the superficial ocular surface, the corresponding inclination of the crystalline columns to one another, the size of their individual transverse sections, and their lengths. The continuous retinal picture in the simple eye is psychically interpreted as a continuous image. If, therefore, the possessor of a compound eye perceives a continuous image of an object, it must be the result of a more complex psychical operation, in virtue of which, the separate portions of the ocular mosaic picture are psychically combined, and interpreted as a continuous whole.

The successive researches of Treviranus, Gottsche, Hannover, Pacini, H. Müller, and Kölliker, have determined the existence and general structure of close-set rods or columns, which extend between the inner and outer surfaces of the retina, in the midst of the nervous and vascular textures of that membrane. The outer extremities of these rods present a crystalline columnar aspect, and constitute, collectively, the external layer of the retina, usually

termed Jacob's membrane. The ultimate filaments of the optic nerve, after being connected in a plexiform arrangement in the ganglionic layer of the retina, terminate each independently, in the more perfect portion of the retinal field, by passing into, or becoming continuous with, the inner end or side of a rod. Kölliker considers these nodes as nervous structures, that is, as terminal portions of the nerve-filaments themselves, and holds that they constitute the parts of the nervous structure of the eye on which objective light primarily acts.

Having myself carefully examined the structures to which I have now alluded, I have been able to verify the more important anatomical details, as described by their discoverers, and agree with Kölliker in considering the rods as the primary optic apparatus. I cannot, however, coincide with this distinguished observer in holding these rods as modified nerve filaments. I hold them to be special structures appended to the extremities of the ultimate nerve filaments, and referable to the same category as the Pacinian bodies, touch-corpuscles, rods of Corti, &c.; and moreover, so far am I from coinciding with Kölliker in his speculations as to the part of the rod on which the objective light acts, that I have found myself compelled, not only from the consideration of the structures themselves, but also from the development of the eye itself, and the arrangements of the compound eye, to conceive the rays of light as acting upon the retina, not as they impinge upon it, or pass through it from before, but as they pass backward again out of the eye after reflection from the choroid.

The general aspect of the rods, and more especially of those portions termed Müllerian filaments, where they collectively amalgamate in the limitary membrane of the retina, indicate, as I believe will be generally admitted, that they consist of a modification of connective tissue, enveloping and supporting the extremities of the ultimate nerve filaments in such a manner as to form special structures, which, from their functions, may be termed *photæsthetic bodies.*

That special structures are required for the initiation of action in the filaments of the optic nerve by objective light, appears to be established by the facts, that the nervous filaments of the retina, and the cut extremities of these filaments on the stump of the optic nerve, are not affected by it, although irritation of the same filaments by electrical or other means produces subjective luminous phe-

nomena. Subjective sounds may be produced by various modes of irritation; but actual sonant vibrations can only excite the acoustic filaments through the medium of the rods of Corti, or the corresponding terminal structures in the vestibule. Corresponding terminal structures are in like manner appended to the tactile, olfactory, and gustatory nerves, apparently for a similar purpose, to provide the necessary conditions of the initial excitement of the nervous current by those secondary properties of external bodies to which the organs of touch, taste, and smell, are related.

When the attention of anatomists was directed, a few years ago, to the structure and physiological signification of the columns of the retina by the observations of H. Müller and Kölliker, I became satisfied that those structures are not, as the latter asserted, nervous structures, properly so called, but special structures, of the same nature as the Pacinian bodies and the tactile corpuscles. I stated and explained my opinion of the nature of these bodies in a lecture on the retina delivered and reported in 1854. But I had generalized these relations of nervous filaments to special terminal exciting structures, still further, in the zoological lectures which I delivered in 1853, for my late distinguished colleague and preceptor Professor Jameson. I also expounded it at considerable length in my course of lectures last winter (1855-6). I shall now state the doctrine in general terms, not only because it is necessary for the elucidation of the distinctive characters of the simple and compound forms of eye; but also because I am anxious to put on record, by submitting it to this Society, a generalization which appears to me of primary importance in the general physiology of the nervous system. I assume, as established, the doctrine of Du Bois Raymond, that a nerve filament is capable of propagating the nervous current equally well in both directions; and that the physical and physiological characters of this current differ in no respect, are in fact identical in the so-called motor and in the so-called sensory filaments, whether special or common, I also assume as established, that the specific manner in which a centripetal nerve current is converted at the central extremity of the filament, that is to say, is physiologically reflected into motor filaments, or, psychically interpreted as sensation, depends upon the physiological or psychical endowments of the different portions of the nervous centre with which the filaments are connected. These two positions being assumed,

then, I hold that, although the ultimate nervous filament may have its functional current (that is the common nervous current), excited or initiated by electrical or other physical or chemical agencies, yet this current can only be initiated or excited, for the special functional purposes for which each nervous filament is provided in the economy, by the structure or tissue with which such filament is connected peripherally. If so, then, not only are the individual filaments of the nerves of special sense provided with current-exciting structures at their peripheral extremities, by means of which alone the objects to which they are related can initiate the nerve current; but also centripetal nerve filaments of whatever kind, are provided, in their connection with the] textures from which they proceed, with arrangements, by means of which alone their functional currents can be initiated.

From this point of view, every particular structure in the organism from which nervous filaments proceed to the nervous centre, may be considered with reference to the nervous system, as a peripheral nervous organ,—that is, an organ capable of exciting or initiating centripetal nerve current; which is physiologically converted, or psychically interpreted at the corresponding central organ, according to the special endowments of that central organ.

After this preliminary statement, I am in a position from which I can explain the mode in which I understand the structure and actions of the rods of the retina in the simple, and the columns in the compound eye.

1. *In the simple eye.*—A ray of light can only impress an ultimate retinal nervous filament under certain conditions. These conditions are, that it should impinge upon the distal extremity of the filament in, or parallel to, the axis of that filament, or within a certain angle to that axis.

All rays impinging on the distal extremity of an ultimate retinal nervous filament under the conditions stated I term *photogenic* rays. Rays impinging upon, or passing through, the filament in any other direction, may be termed *aphotogenic*. The distal portion of the ultimate retinal nervous filament, I distinguish as the *photæsthetic surface*.

In order that the ultimate retinal nervous filament may be subjected to the rays of light under the required conditions of vision, its distal extremity or photæsthetic surface is inclosed in a peculiar

structure, consisting of a so-called *rod* or *cone* (which I distinguish as the crystalline column), and its appended Müllerian filament, with its nuclear enlargements. This structure constitutes a specific kind of peripheral nervous organ, which, from its function, I term a *photæsthetic body*.

A photæsthetic body consists of a distal segment, or dioptric portion, elongated, cylindrical, or club-shaped, homogeneous, transparent, and highly refractive, usually termed the rod or cone; and a proximal segment or peduncle, with its nuclear enlargements, into which the ultimate nervous filament passes, and within which it apparently terminates, probably at its outer end.

The entire aspect and arrangement of these photæsthetic bodies, their predominance over the other parts of the retina at the axial spot of the eye, and the direct continuity of their stems with the nerve filaments at that spot, appear to me to indicate not only the nature of their functions, but also the general features of the mode in which it is effected. It appears to me that the rays which act upon the nervous filaments, must be such rays as the arrangement permits to pass from behind, forwards in the axis of the photæsthetic bodies. It has now been ascertained, that the quantity of light reflected, and consequently irregularly dispersed within the eyeball from the choroid, and bacillary layer, &c. is very considerable; and it consequently becomes a very important question, to determine in what manner this reflected and irregularly dispersed light is prevented from affecting the retina. The view which I have already given of the structure and probable mode of action of the photæsthetic bodies, affords the basis of a hypothesis which meets all the conditions of the question, and is in full accordance with the comparative anatomy and development of the organ of vision. I cannot interpret the functions of the structure of the retina as now determined, except by assuming that the photæsthetic columns are impressed not by the light as it enters the eye, or as it is more or less irregularly reflected and dispersed in its interior, but only by those rays which, in their passage backwards to the pupil pass along, or nearly in the axes of the crystalline rods or columns of the photæsthetic bodies, so as to reach the photæsthetic spots under the required conditions. No confusion, therefore, can result from the multitude of convergent and divergent rays which pass through the chamber of the eye, and through the retina. By this means, the

numerous rays not necessary for vision, are as it were eliminated from the operation, the eye being blind to them, and affected only by such as are reflected backwards to the pupil along the axes of the crystalline columns.

2. *The Crystalline Columns of the Compound Eye.*—As stated in my lecture on the retina formerly alluded to, I conceive the crystalline columns in the eye of the insect or crab, to act in the same manner as the retinal rods in the spheroidal or simple eye. That they do so, may be held as established by the researches of J. Müller on the laws of vision in the compound eye. Müller even refers to the columnar structure of the retina, as presenting a certain similarity to the structure or arrangement of the compound eye. F. Leydig, in an elaborate memoir published in Müller's Archiv in 1855, on the structure generally of the Arthropoda, examines minutely the structure of the simple and compound eyes, and arrives at the conclusion that the crystalline columns of their compound eyes, as well as the corresponding structures in their so-called simple eyes or ocelli, are of the same nature as the so-called rods and cones, that is, the photæsthetic bodies which I have already described in the retina of the proper simple or vertebrate eye. But Leydig entirely loses sight of a fact, which if unexplained, vitiates his conclusion as to the physiological identity of the bodies in question. In the annulose or molluscous eye, whether in its so-called simple or compound form, the crystalline columns are directed like the tubes of so many telescopes towards the object, the corresponding nervous filaments passing to them from behind; whereas the crystalline rods of the vertebrate retina are directed away from the object, that is, towards the back of the eye —are in contact in fact with the choroid, while their nervous filaments are connected to them in front, that is, between them and the object.

On the other hand, if I am correct in holding that the vertebrate eye is acted upon by those rays only which are reflected from its choroidal surface, I have not only explained physiologically why its retinal columns are reversed; but I am legitimately entitled, as Leydig is not, to consider them as the homologues of the crystalline columns of the annulose and molluscous eye.

But the teleological explanation of the opposite arrangement of the corresponding structures in the vertebrate and invertebrate eye,

is, in the present phase of the science, insufficient. The difference must be explained morphologically. This explanation is afforded by the different modes in which the vertebrate and invertebrate, that is, the simple and compound eyes are developed.

In the compound eye the primordial ocular papilla or convexity, which is only slightly protuberant, has its cutaneous or superficial surface immediately converted into the crystalline columnar structure, the individual columns of which are connected with the filaments of the subjacent optic nerve. The columns are all therefore directed to the object.

The primordial cerebro-cutaneous spheroidal protuberance or papilla of the simple refracting or vertebrate eye, is speedily hollowed out in front by the development in or upon it of the lens and vitreous humour, so that from a spheroidal convex surface the primordial protuberance assumes the form of a cup, with its mouth directed forwards, and its cavity occupied by the refracting media of the organ. This cup-shaped mass is the retina; the crystalline rods are not developed on its concave surface, but on its outer or convex surface, as they exist on the convexity of the compound eye, that is, in the direction of the radii of the sphere, but directed backwards, on account of the nearly spheroidal surface.

In conclusion, I may state, what appears to be the physiological superiority of the simple over the compound eye. As the simple eye is acted on by reflected light only, it cannot be disturbed by rays not required for the definition of the image. It is also arranged so as to admit of a much more delicate or minute mosaic representation of the object, from its microscopic and reversed photæsthetic bodies being in contact with the reflecting choroidal surface on which that image is formed. It moreover combines the advantages of the continuous image, formed by the lenticular structures and the mosaic image, which results from its crystalline rods.

The following Gentleman was admitted an Ordinary Fellow:—

Thomas Login, Esq., Civil Engineer, India.

The following Donations to the Library were announced:—

Monthly Return of the Births, Deaths, and Marriages, registered in the eight principal towns of Scotland, with the causes of

Death at four periods of life, for February 1857; and Supplement to Monthly Returns for year 1856. 8vo.—*From the Registrar-General.*

Journal of the Asiatic Society of Bengal, No. 7, 1856.—*From the Society.*

Proceedings of the Royal Astronomical Society, Vol. XVII., No. 4. 8vo.—*From the Society.*

Memoirs, &c., of the Geological Survey of the United Kingdom, viz.:—

1. Figures and Descriptions Illustrative of British Organic Remains, 4to. Decades 5 and 8.
2. The Iron Ores of Great Britain. Part I.—The Iron Ores of the North and North-Midland Counties of England. 8vo.
3. Mineral Statistics of the United Kingdom of Great Britain and Ireland, for 1853-55. By R. Hunt, F.R.S. 8vo.
4. Geology of the Country around Cheltenham. By Edward Hull, A.B. 8vo.
5. On the Tertiary Fluvio-Marine Formation of the Isle of Wight. By Edward Forbes, F.R.S. 8vo.
6. Prospectus of the Metropolitan School of Science applied to Mining and the Arts. 6th Session, 1856-57.
7. Collection of Maps and Sections.
8. Annual Report of the Director-General of the Geological Survey.—*From Sir Roderick Murchison.*

Almanaque Nautico para 1858, calculado de Orden de S. M. en el observatorio de Marina de la Ciudad de San Fernando. 8vo.—*From the Observatory.*

The Assurance Magazine, and Journal of the Institute of Actuaries, April 1857. 8vo.—*From the Institute.*

Memoir on the Roman Garrison at Mancunium; and its probable influence on the Population and Language of South Lancashire. By James Black, M.D., F.G.S. 8vo.—*From the Author.*

Monatsbericht der Koniglichen Preuss. Akademie der Wissenschaften zu Berlin. Juli 1855—August 1856. 8vo.—*From the Academy.*

Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin. 1855, 4to. Erster Supplement,—Band. 1854. Folio. —*From the Academy.*

A General Catalogue of the Principal Fixed Stars, from Observations made at the Hon. East India Company's Observatory at Madras in the years 1830-43. By T. Glanville Taylor, F.R.S. 4to.—*From the Hon. E. I. Company.*

Astronomical Observations made at the Hon. East India Company's Observatory at Madras, in the years 1843-47; together with the Recomputation of the Sun and Moon, and Planetary Observations, since 1831. By T. Glanville Taylor, F.R.S. 4to.—*From the Hon. East India Company.*

Astronomical Observations made at the Hon. East India Company's Observatory at Madras. By Capt. W. K. Worster and W. S. Jacob. 1848-52. 4to.—*From the Hon. E. I. Company.*

Revenue Meteorological Statements of the North-Western Provinces, for the several Official years from 1844-45 to 1849-50. 4to. —*From the Hon. E. I. Company.*

Meteorological Register kept at the Hon. East India Company's Observatory at Madras. By J. Goldingham, F.R.S., and T. Glanville Taylor, F.R.S., for the years 1822-43. Folio.—*From the Hon. E. I. Company.*

Monday, 20th April 1857.

Dr CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. On the recently discovered Glacial Phenomena of Arthur's Seat and Salisbury Crags. By Robert Chambers, Esq.

It will be remembered that, when the cutting was made, early in 1846, athwart the shoulder of Arthur's Seat above Samson's Ribs, for the formation of the Queen's Drive, the rock was found hollowed in a trough-form for a space of about eighty yards, and smoothed and striated in the manner of a glacier-bed of the Alps. The striæ were in the direction of the hollow, pointing to east 20° south. The whole was covered over with a brown tenacious clay, containing fragments of rocks of the district, along with some supposed to have

come from a distance. The phenomena were carefully observed at the time, and reported on to this Society by our associate Mr David Milne (now Mr Milne-Home).

The formation of a road to Duddingston along the south side of Arthur's Seat has, during the first three months of this year, revealed a set of phenomena precisely similar in character, at the well-known pass of Windygowl, through which it was necessary to make a deep cutting. This pass, it may be remarked, was simply a low point or breach in the crest of an upturned bed of porphyritic greenstone which comes prominently out to the south in the form of what is called the *Girnel Crag*, and on the other side loses itself in the mass of the hill, the dip being to the north-east. When the surface matter was taken off at this place, a tenacious brown clay was disclosed, very much like that which had formed the covering of the smoothed rocks above Samson's Ribs. When this was removed, the upturned edges of the greenstone bed were laid bare; basseting of course towards the south-west; and all were found to be rounded, smoothed, and striated, the striæ lying in nearly an east and west direction. The rocky outline formed an irregular hollow, of which about six feet was thus worn, being the portion heretofore covered with clay, while about thirty feet more was composed of the rough weather-worn cliffs of the Girnel Crag on the one hand and the hill-side on the other. The only difference between the hollow here laid bare and that formerly exposed at Samson's Ribs, was that the rocks were less worn down. There was not here, as in the other case, a complete trough with smooth sides or walls, and every longitudinal chink worn, as I remember to have observed, down to the bottom, as if by some searching—I might say insinuating—agent. We only saw a rude hollow, whose irregularities had been partially ground down—the same work, as it were, half done. There was not, however, a single prominent face of rock within the hollow which did not show more or less of rounding, smoothing, and streaking. It is worthy of remark that these appearances were not confined to the immediate gorge cut in the Girnel Crag, which was not more than ten yards in extent, but were partially observed on prominent surfaces of the hill-side for fully fifty yards to the westward.

Immediately to the east of the gorge, the cutting, though descending at a rapid angle towards the lake, did not reach the rock. It

presented, however, a deep section of superficial matters. First was the compact blue or boulder clay containing small stones. Next was a rough brown clay drift, containing large boulders, all rounded, and many of them smoothed and scratched. Over this lay a bed of tolerably pure sand, and over all was a thick deposit of debris from the hill-side, including many large angular masses. The boulders in the clay beds have been reported on as from the rocks of the district. One which lay in the brown drift just beyond the gorge, to the eastward, was a square mass of arenaceous limestone, probably from a bed in the hill-side little more than a hundred yards to the westward. It was three feet long by twenty inches broad, and was split up by the workmen into six slabs, exposing a multitude of the characteristic conchifers of the formation to which the bed belongs, besides a few vegetable remains, apparently calamites. What was very remarkable, this block bore the glacial dressing with striæ on two sides crossing the planes of stratification, and further seemed partially water-worn on one of its ends.

It is important to remark that the boulders were all of eastward transport, and in perfect accordance with this fact was that of the deep section of superficial matters being presented to the eastward of the gorge. A precisely similar deposit being found to the east of the Loch Crag, between Windygowl and Duddingston, we may fairly conclude that the westward side of these prominent masses was the *stoss seite* or *exposed side*, and the eastward the *lee side*, with regard to the movement of the agent by which the attrition was produced.

The operations for the new road within the garden to the north of Duddingston Church have since laid bare a sloping face of exceedingly hard greenstone, which had been only covered with a thin bed of vegetable soil. I am assured that this face, though not smoothed or marked with striæ, was dressed and channeled in much the same manner as the well-known surfaces on the west slope of the Costorphine Hill, which were first described by Sir James Hall.

It is worthy of notice that the smoothed hollow above Samson's Ribs was 385 feet above the level of the sea. The ice-worn pass at Windygowl is about 180 feet above the sea.

Glacially-marked surfaces have within the last few years been laid bare at three other places in this group of hills.

The most remarkable was at the north foot of Arthur's Seat, close beneath the line of the North British Railway, and within the precincts of the St Margaret's Station. It was a swelling piece of surface, fully thirty feet each way, and all beautifully polished and scratched, the striæ pointing to E. 15° N. Many greenstone boulders of large size, generally with flattened and polished soles, marked with striæ in the line of greatest length, were taken out of the clay-drift which overlay this surface.

About two years ago, the officers of H. M. Office of Works were good enough, at my request, to lay bare a few yards of the surface of the trap-bed near the summit of Salisbury Crags. The exposed space was found to be worn down into a smooth slope, with shallow channelings and deeply cut striæ in the line of the inclination, E. 15° N. Many of these striæ could be traced for one or two yards; and throughout a space of fifty feet along the summit of the hill, they were all of uniform character. The cliff has here been quarried away, so as to form a deep *sinus*, and, as the lines go up to the present verge, it is of course to be presumed that they had originally gone much farther.

What is, however, most remarkable in this instance, is the clear presence of a system of cross scratching, of posterior date, and quite as evidently the result of natural causes. These scratches are generally less than one foot long, and only impressed on the swelling interspaces between the channelings already described. They point to E. 20° S., being a difference of 35° from the direction of the earlier and more general striation. It is worthy of remark, that the summit of Arthur's Seat lies pretty nearly in the centre of the separating lines.

Professor Fleming having some years ago observed some glacial markings on the verge of a projecting piece of rock, at a spot called the Egg Pond, about 150 feet above St Anthony's Chapel, I had an exposure made there, by favour of the Government Officers, to the extent of two or three yards. This surface is flattened, polished, and marked with striæ pointing to E. 15° N.

The Egg Pond, it may be further remarked, beside which this smoothed surface is presented, is a now dry hollow, forming part of a little narrow valley which here indents for 150 yards the haunch of the hill. It is a circumstance not without its significance, that this little valley or trough lies in precisely the same direction

as the striæ of the smoothed rock. There is a hollow precisely similar immediately under the summit of Arthur's Seat, to the north, with a ridge of equal length forming its boundary in that direction. This valley and this ridge lie in the same line, namely, pointing to E. 15° N.

On the north haunch of Arthur's Seat there are many exposed trap surfaces of a rounded form, but much weathered, and sometimes greatly shattered. These may be considered as *roches moutonnées* in a state of extreme decay.

I have only to remind the Society of what Mr Maclaren pointed out many years ago, that fragments of the trap of Salisbury Crags are scattered over the back of that hill, and in some instances have been transported across the valley, and placed higher on Arthur's Seat than any part of the parent hill now is. One has settled a little above the hollow just described as existing under the summit of Arthur's Seat. From the very hard greenstone, again, which constitutes the south haunch of the Lion, large blocks are carried eastward along the slope of the hill to the extremity of the park in that direction.

It will be observed, that amongst the whole phenomena, old and new, there are some remarkable harmonies. All the drifted matters have been carried eastward. The prominences are all abrupt towards the west, while to the eastward they are tailed away, affording on that side shelter to accumulations of loose matter. The striæ in four exposed surfaces of the two hills, and two remarkable troughs or hollows on Arthur's Seat, are coincident in direction, namely, between W. 15° S. and E. 15° N., being precisely the direction in which the striæ in numberless other places throughout this district, and all the longitudinally-shaped hills and hollows also, are disposed. Overlooking the somewhat discrepant direction of the hollow over Samson's Ribs,—for which some accidental cause may be speculated on,—this uniformity in the phenomena may be said to speak strongly for the deep ice-current, which I have long upheld as necessarily to be assumed, to account for a large class of appearances in Scotland, as I believe also in Scandinavia and in North America.

I have already pointed out, however, that ice has operated in more ways than one in our country.* The traces of a later glacial system

* Reference is made to a paper which I had the honour to read to the Society in December 1852, and which is published in Jameson's Journal for April 1853.

—a system of local subaerial glaciers—are abundant throughout all the alpine grounds of Scotland, as well as those of Cumberland and Wales. By these the boulder clay—the result of the original and general ice-work—has been swept out of many valleys, and ordinary moraine detritus left in its stead in more partial situations. One of the most notable memorials of local glaciers in our island is the curving ridge of detritus forming the dam which retains a mountain lake. Examples are to be seen at Lochs Whorral and Brandy on the eastern skirts of the Grampians, at Loch Skene in Dumfries-shire, and Llyn Idwal in Wales. In many places, a north-looking *sinus* in a mountain has such a curving ridge of detritus girdling it in front, without any lake. Keeping in view these objects, of which I have now seen a considerable number, I am inclined to think that the valley between Arthur's Seat and Salisbury Crags has been the seat of a glacier, and that its moraine is still to be seen at the lower end, near the bleaching-green. There is certainly at that spot a broad *agger* of detrital matter, including many rough blocks, and which has all the appearance of having once confined a lake, the breach by which the water was discharged being still visible. That this lake existed so lately as the reign of Mary is tolerably well evidenced by a passage in Marjoribanks' *Annals*, where it is stated that, at the marriage of Lord Fleming to the daughter of Lord Ross, in May 1564, "the banquet was made in the park of Holyrood House, *under Arthur's Seat, at the end of the loch*, the Queen's grace being present,"—this description being scarcely applicable to any other place. It may be considered as favourable to this view of the former condition of the Hunter's Bog, that very few blocks lie there, in comparison with the multitudes which are scattered over the mountain sides. In other papers I have proved that the system of local and subaerial glaciers was preceded as well as followed by a submersion; from which it may be inferred that it was a period of elevation,—perhaps of such elevation as to bring the higher grounds of our island within the snow-line,—being all that was required to produce the phenomena to be accounted for.

2. On a Dynamical Top, for exhibiting the Phenomena of the Motion of a System of invariable form about a Fixed Point; with some suggestions as to the Earth's Motion. By Professor Clerk Maxwell.

The top is an instrument similar to that exhibited by the author at the meeting of the British Association in 1856. It differs from it in being of smaller size and entirely of brass, except the ends of the axle; and in having six horizontal adjusting screws and three vertical ones, instead of four of each kind.

It consists of a hollow cone, with a heavy ring round the base, and an axle, terminating in a steel point, screwing through the vertex. In the ring are the nine adjusting screws, and on the axle is a heavy bob, which may be fixed at any height.

By means of these adjustments the centre of gravity of the whole is made to coincide with the steel point, and the axle of the top is made one of the principal axes of the *central ellipsoid*.

The whole theory of the spinning of such a system about its centre of gravity depends on the form of Poinsot's ellipsoid corresponding to the particular arrangement of the screws. The top is intended to exhibit those cases in which the three axes of this ellipsoid are nearly equal. In these cases the instantaneous axis is never far from the normal to the invariable plane, which we may call the invariable axis. This axis is fixed in space, but not in the body; for it describes, with respect to the body, a cone of the second order, whose axis is either the greatest or the least of the principal axes of inertia.

To observe the path of the invariable axis in the rapidly revolving body, we must have the means of recognizing the part of the body through which it passes at any time. For this purpose a disc of card is placed near the upper end of the axle. The four quadrants of this disc are painted red, yellow, green, and blue, and various other marks are added; so that by observing the colour of the spot which appears the centre of motion, and the diameter of the coloured spot, the position of the invariable axis in the body at any instant may be known, and its path traced out.

This path is a conic section, whose centre is in the principal axis. If that axis be the greatest or least, it is an ellipse with its major

axis parallel to the mean axis. If the axle of the top be the mean axis, the path is an hyperbola as projected on the disc.

When the axle is the axis of greatest inertia, the direction of motion in the ellipse is the same as the direction of rotation. When it is the axis of least inertia these directions are opposite. All these results may be deduced from Poinsot's theory, and verified by means of the coloured disc.

The theory of precession may be illustrated by this top in the way pointed out by Mr Elliot, by bringing the centre of gravity to a point a little below or above the point of support.

The theory and experiments with the top suggest the question—Does the earth revolve *accurately* about a principal axis? If not, then a change of the position of the axis will take place, not in space, but with respect to the earth, so that the apparent positions of stars with respect to the pole will remain the same, but the latitude of every place will undergo a periodic variation, whose period is about 325 days. To detect this variation, the observations of Polaris with the Greenwich transit circle for four years have been examined. There appeared some doubtful indications of a variation not exceeding half a second. A more extensive investigation would be required to determine accurately the period, and the epoch of maximum latitude at a given observatory, which must depend on the longitude of the station, as the pole of the "invariable" axis travels round the mean axis from west to east.

3. On the true Signification of certain Reproductive Phenomena in the Polyzoa. By Dr Allman.

When the reproductive phenomena of Alcyonella, as manifested both in gemmation and true generation, are viewed in their proper sequence, they will be found to present a series of acts which admit of an obvious comparison with the class of phenomena commonly known as the "alternation of generations."

From the fecundated ovum an embryo is produced in the ordinary way after the segmentation of the vitellus. In this embryo, which presents at first the form of a locomotive ciliated sac, sexual organs are never directly developed, but there are produced within it by a process of *gemmation* the following series of zooids. 1. A polypide, which, like the containing sac, is essentially nonsexual, and which is eminently organized for the functions of digestion. 2. A

peculiar bud, at first undistinguishable from the polypide-bud, but which never develops digestive organs, and is soon seen to be filled with proper ova, each with its germinal vesicle and germinal spot. This body, may, in accordance with common usage, be called the ovary of the zooid from which it is developed, but since it is produced from this zooid in the manner of a bud, exactly as the polypide is, it may itself be fairly viewed as a unisexual zooid, in which the whole organization becomes subservient to the reproductive function, while all the other functions and their special organs become masked and suppressed by the dominant development of the organization destined for generation. 3. Another unisexual bud developed upon the polypide, endowed with a male function and commonly called the testis, but truly a distinct zooid, with its whole organization rendered subservient, as in the ovary bud, to generation. 4. A nonsexual bud of peculiar form (the statoblast) also developed from the polypide.

The esential features in the reproductive phenomena just enumerated, present themselves in an indefinitely repeated series, where the first and last terms of each cycle consist in a fecundated ovum, and the intermediate terms in a succession of gemmæ.

4. On the Destructive Distillation of Animal Matters. Part IV. By Dr Anderson, Glasgow.

5. Analysis of Specimens of Ancient British, of Red Indian, and of Roman Pottery. By Murray Thomson.

Ancient British Pottery.

The specimen of this pottery was found last spring (1856) on the property of William Stirling, Esq. of Keir, along with the remains of a human skeleton, and so broken into fragments as to be of no archæological value

The clay, or rather loam, from which this pottery had been made had evidently undergone little or no previous preparation; the fragments were brittle, and had not been highly fired;—in this respect being inferior to the pottery of the Ojibbeway Indians about to be described. The fractured edges of the pieces presented two layers, the outside one of a dun hue, the inner black; but neither of the surfaces was glazed. Its brittleness rendered this pottery easily reduced to powder, which had a uniform olive-brown colour.

	No. 1.	No. 2.	Mean.
Silica, ...	52·49	51·24	51·86
Alumina, ...	13·29	12·46	12·87
Peroxide of iron, containing phosphates corresponding to 1·01 Phosph. Acid, and also a trace of Manganese,	18·19	18·94	18·56
Lime, ...	4·85	5·13	4·99
Magnesia, ...	0·60	1·64	1·12
Soda, ...	3·06	2·97	3·01
Potass, ...	0·55	0·78	0·66
Organic matter, . . .	2·14	2·33	2·23
Water, ...	4·70	4·76	4·73
	99·87	100·25	100·23

Ojibbeway Pottery.

The specimen of this ware which I examined, in general appearance very much resembled the Ancient British Pottery, being like it made of unprepared clay, marked on one of its surfaces by lines forming part of some simple design. In colour, the surfaces of this ware were whity-brown. The section of the fragments presented a black appearance, almost as if the clay previous to firing had been mixed with some carbonaceous substance. It was, however, better fired than the British ware, and rung to some extent when two pieces were struck together.

	No. 1.	No. 2.	Mean.
Silica, . .	42·70	43·60	43·15
Alumina, . .	22·71	22·12	22·41
Peroxide of iron, .	10·58	10·03	10·30
Lime, . .	1·33	1·46	1·39
Magnesia, .	2·60	2·88	2·74
Organic matter, .	10·28	10·10	10·01
Water, . .	9·79	9·99	9·89
	100·19	100·18	100·185

Lustrous Red Roman or Samian Ware.

This pottery has already been analysed more than once, and my analysis was only confirmatory of those already published. It would appear that in many of those pottery clays peroxide of iron can to a very great extent replace alumina, for, in the specimen I ana-

lysed, the oxide of iron is in greater quantity than the alumina; while in all the analyses of this pottery I have seen, the alumina is the greater.

The specimen of this ware which I analysed was procured from the Museum of the Society of Antiquaries, Edinburgh.

After the analysis of the mass of this pottery was finished, I scraped several of the pieces at my disposal, so as to ascertain the composition of the glaze of this beautiful ware. I could only procure enough for a qualitative analysis; but this was sufficient to show a circumstance already noticed about this pottery, namely, that its glaze contains no tin, lead, or antimony, or any of the heavy metals.

Silica,	54·78
Peroxide of iron, containing phosphates corresponding to 0·42 Phosph. Acid,	21·43
Alumina,	8·74
Lime,	12·67
Magnesia,	1·33
Water,	1·26
	100·21

6. Theory of Linear Vibrations. Part VI. Alligated Vibrations. By Edward Sang.

This part of the paper contains an inquiry into the action of a vibrating body upon a linear elastic series, as representative of the action of a sound-emitting substance upon the air.

It results that when one end of a linear elastic series is attached to an oscillating substance, all the internal oscillations of which the system is capable when one end of it is fixed, are called into existence; the number of these being equal to the number of the elements in the system, and their periodic times being mutually incommensurable; and that to these is added another, isochronous and synchronous with that of the oscillating substance.

The investigation shows that the whole of these oscillations are instantaneously communicated to the system, and that the state of repose in which it was at first is merely that phase of the general motion in which all the parts but one have their velocities simultaneously zero.

On account of the incommensurability of the times, no periodic return of this or of any other phase can take place, and thus the formation of waves or pulsations in a perfectly elastic uniform linear series is impossible; so that this line of inquiry also fails to give any indications of the velocity with which a vibratory impulse is conveyed from one end of such a series to the other end.

When the periodic time of the oscillating body is exactly equal to that of any of the internal oscillations of the system, the extent augments indefinitely with the time during which the action is continued; a result which would imply that the loudness of a sound should increase with its duration.

The attempt to pass from a discrete to a concrete system by the method of infinitesimals fails, because by augmenting the number of the parts, we also augment the number of the equations of condition, not one of which can be omitted without vitiating the result.

The general conclusions are these:—That the observed phenomena of sound are inconsistent with the supposition of a perfectly elastic vibratory medium, and that either the viscidity, or some as yet unknown quality of the air, has to do essentially with the production of those phenomena, so that any analysis in the present state of our preparatory knowledge must be futile. And that the undulatory theory of light is altogether conjectural, since far from knowing how one supposed wave would influence another, we do not yet know anything of the manner in which such waves can be formed at all.

The following Donations to the Library were announced:—

Transactions of the Royal Society of Literature. Second Series, Vol. V. Part 3.—*From the Society.*

Proceedings of the Royal Astronomical Society. Vol. XVII. No. 5. 8vo.—*From the Society.*

Monatsbericht der Königlichen Preuss. Akademie der Wissenschaften zu Berlin, 8vo. November—December, 1856.—*From the Academy.*

Quarterly Journal of the Geological Society. 8vo. February 1857.—*From the Society.*

Journal of the Proceedings of the Linnæan Society. 8vo. Vol. I. No. 4.

Silliman's American Journal of Science and Arts. 8vo. March 1857.—*From the Editors.*

Proceedings of the Berwickshire Naturalists' Club. 8vo. Vol. III. No. 7.—*From the Club.*

Transactions of the Cambridge Philosophical Society. 4to. Vol. IX. Part 4.—*From the Society.*

Essays and Heads of Lectures on Anatomy, Physiology, Pathology, and Surgery. By the late Alexander Monro, Secundus, M.D., F.R.S.E. With a Memoir of his Life, and Copious Notes, explanatory of Modern Anatomy, Physiology, Pathology, and Practice. By his Son and Successor. 8vo.—*From Dr Monro.*

Army Meteorological Register from 1853 to 1854 inclusive, from Observations made by Officers of the Medical Department of the Army, at Military Posts of the United States. Prepared under direction of Brevet-Brigadier General Thomas Lawson, 4to.—*From Professor Henry D. Rogers.*

Statistical Report of the Sickness and Mortality in the Army of the United States, from 1839 to 1855. By Richard H. Coolidge, M.D. 4to.—*From Professor Henry D. Rogers.*

Reports of Explorations and Surveys to ascertain the most practicable and economical Route for a Railroad from the Mississippi River to the Pacific Ocean, made in 1853-4. 4to. Vol. I. —*From Professor Henry D. Rogers.*

Narrative of the Expedition of an American Squadron to the China Seas and Japan, in the years 1852-54, under command of Commodore M. C. Perry, U.S. Navy. By Francis L. Hawkins, D.D., LL.D. 4to. Vol. I. Also Vol. III. of the same work, being Observations on the Zodiacal Light from April 2, 1853, to April 22, 1855. By Rev. George Jones, A.M. 4to.—*From Professor Henry D. Rogers.*

INDEX.

END OF VOLUME THIRD.

NEILL AND CO., PRINTERS, EDINBURGH.